C.2

OPERATING AND SERVICING MANUAL FOR AUDIO VOLTAGE STANDARD MODEL 323C

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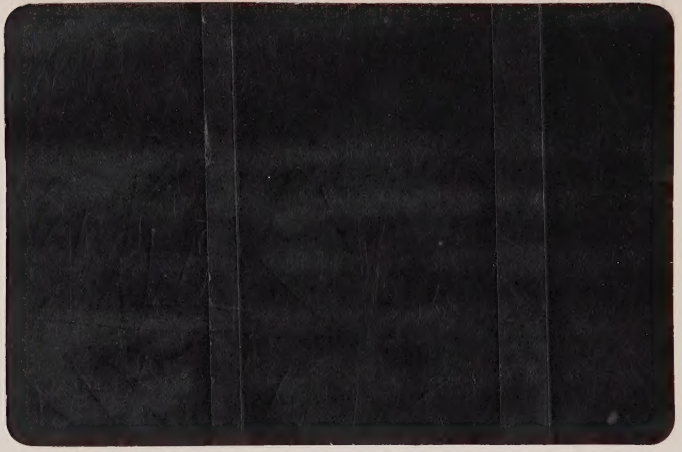

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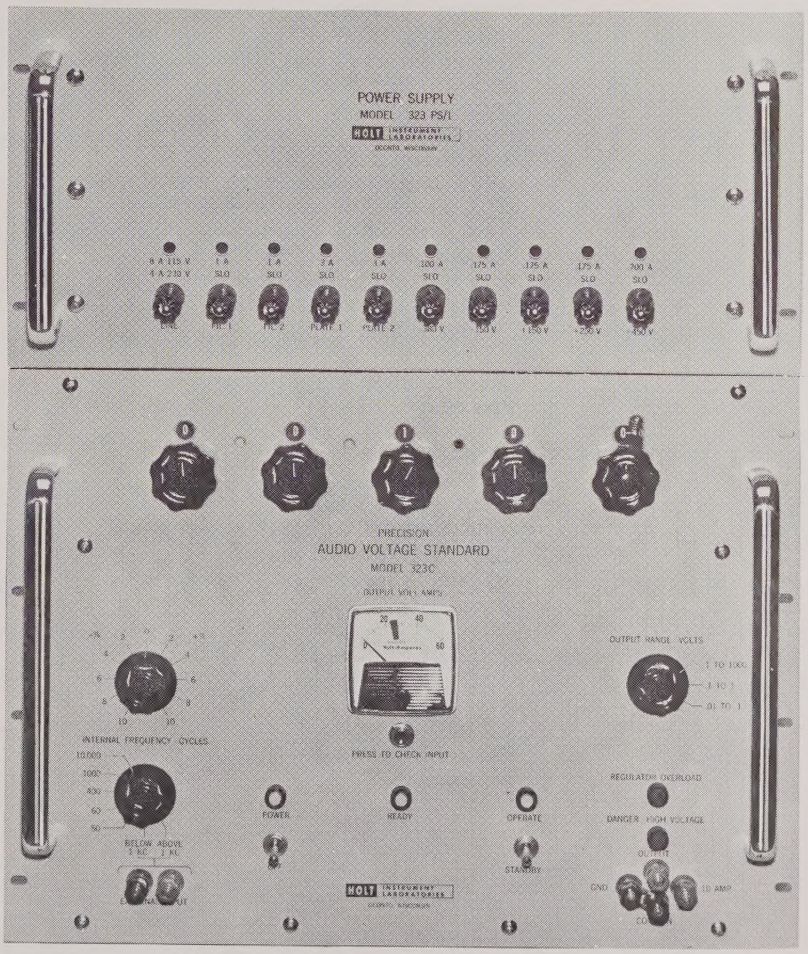

THIS MANUAL TO ACCOMPANY

INSTRUMENT NO. . . . . .

JUNE ~~1966~~ JUN 1968

HOLT INSTRUMENT LABORATORIES

OCONTO, WISCONSIN 54153

68-87-29-15

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ADDENDUM - MODEL 323C

November 24, 1967

These changes have been made in the attenuator of the Model 323C:

Circuit Reference	Description	Holt Part Number
C622	Capacitor, Mylar, .01 mfd, 600 V. 10%	0903-051
L601	Inductor, 500 µH	1502-017
R609	Resistor, W.W, 17.8KΩ, ±.005%	0802-340
R610	Resistor, WW, 15.8 KΩ, ±.005%	0802-339
R611	Resistor, WW, 13.8KΩ, ±.005%	0802-338
R612	Resistor, WW, 11.8 KΩ, ±.005%	0802-337
R613	Resistor, WW, 9.8 KΩ, ±.005%	0802-336
R614	Resistor, WW, 7.8 KΩ, ±.005%	0802-335
R615	Resistor, WW, 5.8 KΩ, ±.005%	0802-334
R616	Resistor, WW, 3.8 KΩ, ±.005%	0802-333
R617	Resistor, WW, 1.8 KΩ, ±.005%	0802-332
R619	Resistor, WW, 1.6 KΩ, ±.005%	0802-327
R620	Resistor, WW, 1.4 KΩ, ±.005%	0802-326
R621	Resistor, WW, 1.2 KΩ, ±.005%	0802-325
R622	Resistor, WW, 1.0 KΩ ±.005%	0802-324
R623	Resistor, WW, 800 Ω, ±.005%	0802-323
R624	Resistor, WW, 600 Ω, ±.005%	0802-322
R625	Resistor, WW, 400 Ω, ±.005%	0802-321
R626	Resistor, WW, 200 Ω, ±.005%	0802-317

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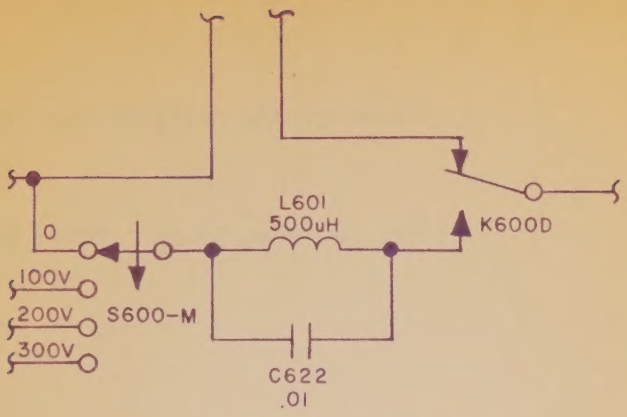
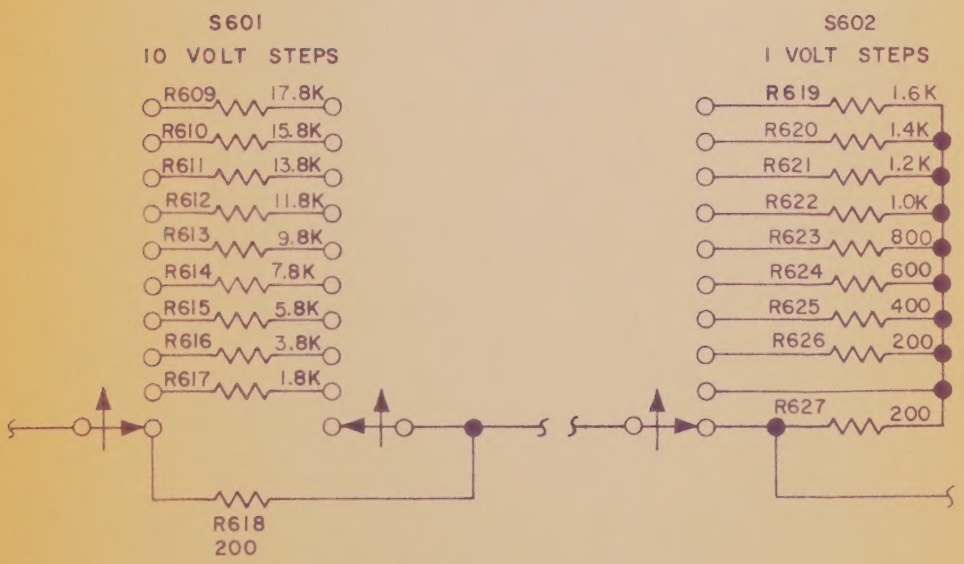
ADDENDUM - MODEL 323C

Nov. 24, 1967





ADDENDUM - MODEL 323C

June 3, 1968

Input power specification should read:

115V/230V ±10%, 50-60 Hz, 750 watts.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or it is damaged in any way, a claim should be filed with the carrier. Also, notify Holt Instrument Laboratories or the local representative immediately. A full report of the damage should be obtained by the claim agent and this report should be forwarded to us. We will advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Holt Instrument Laboratories warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Batteries and thermocouples are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid, and when upon our examination it is to our satisfaction defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify either the factory or the area Holt representative, giving full details of the difficulty, and include the model and serial numbers. Upon receipt of this information we will give you service data or shipping instructions.

2. On the receipt of shipping instructions, forward the instrument prepaid to the factory or the authorized repair station indicated in the instructions. If requested, an estimate of the charges will be made before the work begins if such work is not covered by warranty. All shipment of Holt Instrument Laboratories' equipment should be packed in a strong exterior container surrounded by two or three inches of shock absorbing material.

SECTION 1

INTRODUCTION

1.1 General Description

a. The Holt Audio Voltage Standard, Model 323C is an extremely stable, self-regulated, calibrated source of audio frequency voltage. Its primary function is to act as a precision source of continuously variable sine wave voltage for use in the calibration of other instrumentation.

b. The Model 323C can supply voltages from 10 millivolts to 1000 volts with essentially infinite resolution. The voltage appearing at the output terminals is extremely stable and is indicated on in-line digital readout immediately above the voltage selector switches.

c. The Model 323C provides a frequency range of 35 to 20,000 cycles. An internal oscillator supplies five customer selected frequencies, variable ± 10% in 2% increments. Any external variable frequency source of approximately one volt RMS, such as the Holt Model 448 Audio Oscillator, will enable the unit to provide continuously variable frequency output over the above voltage and frequency ranges.

d. Although the Model 323C was designed primarily as a secondary calibration standard, its power handling capability of 30 voltamperes enables it to be used for many other applications. It can, for instance, calibrate many instruments at one time. It can be used with a transfer standard such as the Holt TV1 to obtain accuracies approaching those of DC measurements. Used in conjunction with an accurate AC voltmeter, it can act as a source for testing transformers, capacitors and inductors since it is virtually insensitive to reactive loads. The ease with which various voltages and frequencies can be dialed make the Model 323C an ideal voltage source for the frequency response testing of amplifiers and filters.

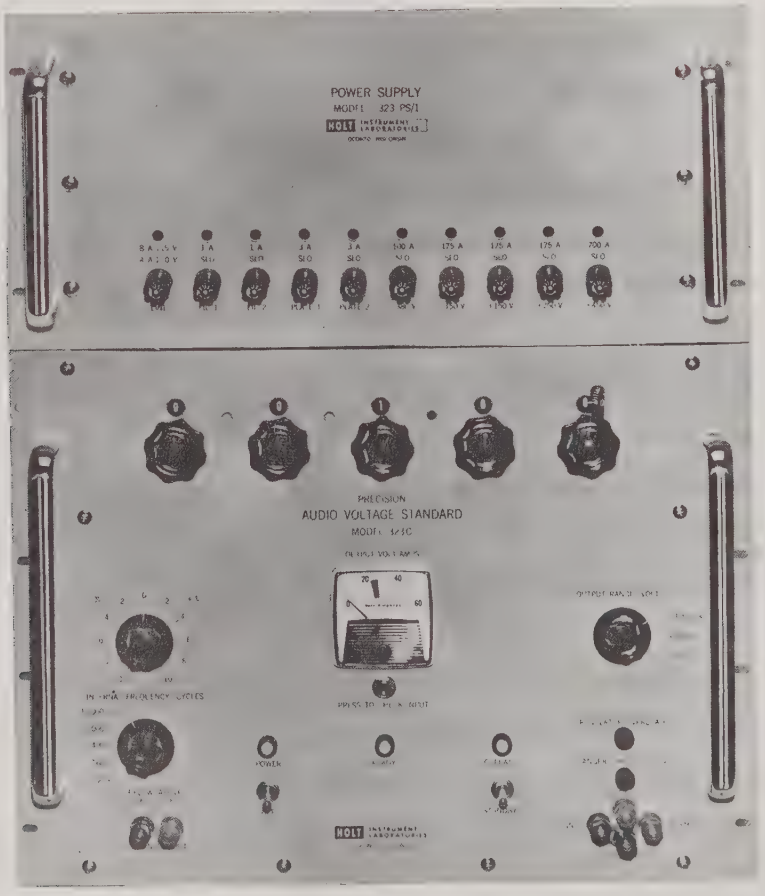


Figure 1. Audio Voltage Standard - Model 323C

TECHNICAL SPECIFICATIONS

VOLTAGE RANGE:

Continuously adjustable by 5 decade switches and a vernier potentiometer.

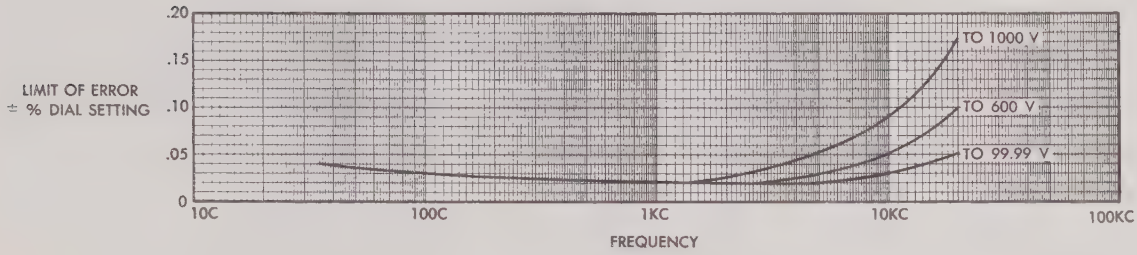
Range:	Dial Resolution:
0.01 V to 0.1 V	2 micro V per division
0.1 V to 1 V	20 micro V per division
1 V to 1000 V	200 micro V per division

ABSOLUTE RMS VOLTAGE ACCURACY - NO LOAD:

Stated as a maximum limit of error (±% of dial setting), including all contributing errors and uncertainties.

Internal Oscillator at:	50,60 cps	400 cps	1KC	10KC
To 99.999 volts - 25 microvolts plus	.035	.025	.020	.035
To 600.000 volts	.035	.025	.020	.050
To 1000.000 volts	.035	.025	.020	.090

For use with external oscillator, refer to curve below:



STABILITY:

Long term calibration (90 days)	See Note 1.	±.02%
Short term amplitude (random)	See Note 2.	±.01%
Beat frequency modulation (near line freq.)		±.10%

FREQUENCY RANGE:

External Oscillator:

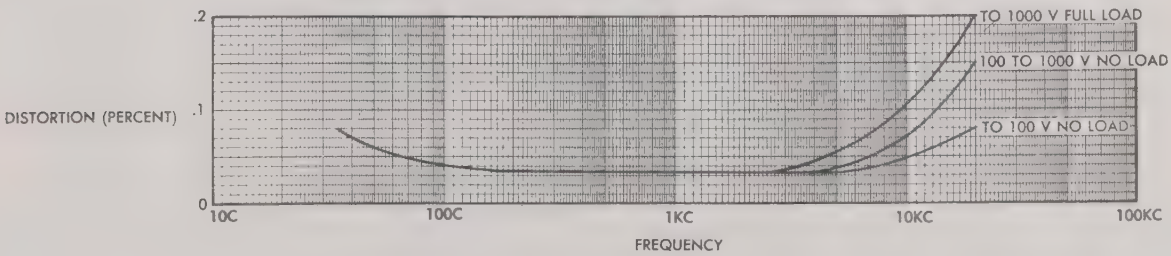
35 cycles to 20 KC. (When using an external oscillator, the Model 323C specifications, especially short term amplitude stability and output distortion, are primarily dependent upon the corresponding oscillator specifications.)

Internal Oscillator:

Any 5 fixed frequencies between 35 cycles and 20 KC.
Standard frequencies are 50 C, 60 C, 400 C, 1 KC and 10 KC.
Special frequencies available for an additional $150 for one or all five.
Each frequency is variable ± 10% in approximate 2% steps.
Frequency Calibration: ± 0.5% after 30 minute warmup.
Frequency Stability: ± 0.1% per hour after 30 minute warmup.

OUTPUT DISTORTION:

Waveform: Sinusoidal.
Total harmonic distortion: (When using internal oscillator)



SPECIAL 1 VOLT OUTPUT:

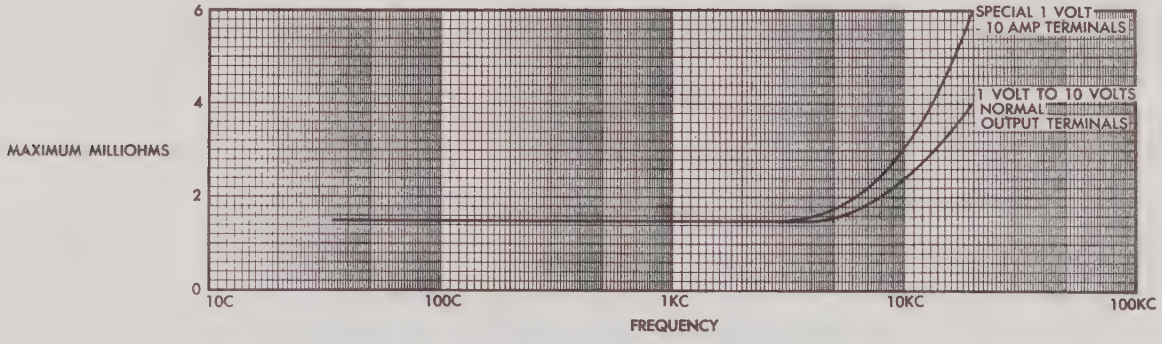
No load calibration: ±0.5%.
10 amperes maximum.
Special 1 volt - 10 ampere output terminals provide a high current source for the calibration of wattmeters and ammeters.

OUTPUT LOAD REGULATION:
(No Load to Full Load)

10 volts to 1000 volts:	.01% maximum to 10 KC. .03% maximum to 20 KC.
Below 10 volts:	Depends on load current, output voltage and output impedance stated below.

OUTPUT IMPEDANCE:

Below 1 volt:	150 milliohms maximum.
1 volt to 10 volts:	As below.



MAXIMUM OUTPUT POWER:

Below 1 volt:	0.5 amperes maximum.
1 V to 9.99 xV:	3 amperes maximum.
10 V to 500 V:	30 volt-amperes or 1 ampere maximum, whichever is less.
Above 500 volts:	to 6 KC 30 volt-amperes. to 20 KC 20 volt-amperes.

LOAD METER: Range: 0 to 60 volt-amperes.
Accuracy: ±10%

SIZE: Regulator: 19" W x 14" H x 15" D.
Power Supply: 19" W x 8-3/4" H x 16" D.

WEIGHT: Regulator: Approximately 90 lbs.
Power Supply: Approximately 90 lbs.

INPUT POWER: 115 V / 220 V ±10%, 50 - 60 cycles, 750 watts.

NOTES:

1. Holt Laboratories feels that good practice requires a periodic test (with NBS traceable test instruments) of any standard, such as the Model 323C, that is used to calibrate other instruments. We recommend a check every 90 days. Experience indicates that calibration adjustment normally is not necessary, but should it be required, the Model 323C has an adjustable reference to permit setting to specified accuracy.

2. When using internal oscillator. This stability permits reading a 5-digit DVM plus or minus one on the least significant digit.

SECTION 2

OPERATING INSTRUCTIONS

2.1 Preparation for Use

a. General. The Audio Voltage Standard is supplied, factory tested and calibrated, in two shipping containers. The customer need only place the two units in position and connect the power cable between them. It requires no preliminary service by the customer other than inspection to be sure all tubes are seated and all plugs and connectors are tight.

b. Power Connections. The power cord is terminated in a three prong, polarized male connector. Connect the large rectangular pin to the common side of the AC power line and the small rectangular pin to the hot side of the line. The large round pin of the connector is wired directly to the chassis of the instrument. It is important that this pin be connected directly to a good earth ground connection. Large amounts of noise or 60 cycle voltage on the instrument chassis may affect the regulation. Be sure the power switch is off before inserting line plug.

c. Power Line Voltage. The instrument is designed for operation on power lines of either 115 or 230 volts ± 10%. Check the transformer connections and the line fuses to be sure they correspond to those in figure 2 for the particular line voltage to be used. The fuses are located on the front panel of the power supply (fig. 4). The transformer connections are accessible by removing the bottom cover of the power supply unit (323 PS/1). See figure 37.

d. Operating Temperatures. The Model 323C and its power supply unit are each equipped with fans to circulate air and prevent overheating. If the units are enclosed in a rack or cabinet, provision must be made for adequate circulation of air to keep the ambient temperatures below 45 degrees C. The internal oscillator thermistors are regulated in an oven. Any condition that will cause the oven to lose control will alter the output of the unit. The precision reference has been temperature compensated at the factory for operation in an ambient varying between 20 and 45 degrees C. Operation in an ambient outside this range will alter the output of the unit.

The six volt supply regulator heat sink is protected by a thermostat that will shut down the unit in the event of overheating. Any excessive rise in temperature may cause this protective device to open.

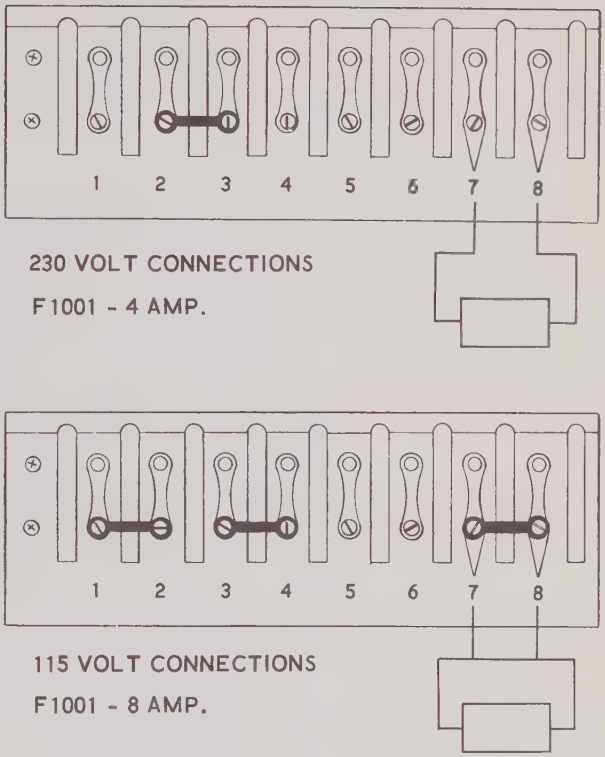


Figure 2. Power Supply Connections

NOTE

Ambient temperature as used here refers to the temperature of the air drawn into the instrument for cooling. This air may be several degrees above the room temperature if there is poor circulation in a rack or cabinet. If the 323 PS/1 is operated or serviced on a bench or table, the air flow above and below the unit must not be obstructed. Rubber feet are supplied with the unit to maintain this required air flow.

The fan filters of the regulator and power supply should be cleaned periodically to insure operation of the unit within its specifications.

2.2 Operating Controls and Indicators

The controls, indicator light, terminals, and fuses located on the front panel are described below. These are the controls used in the normal operation of the Audio Voltage Standard. The in-

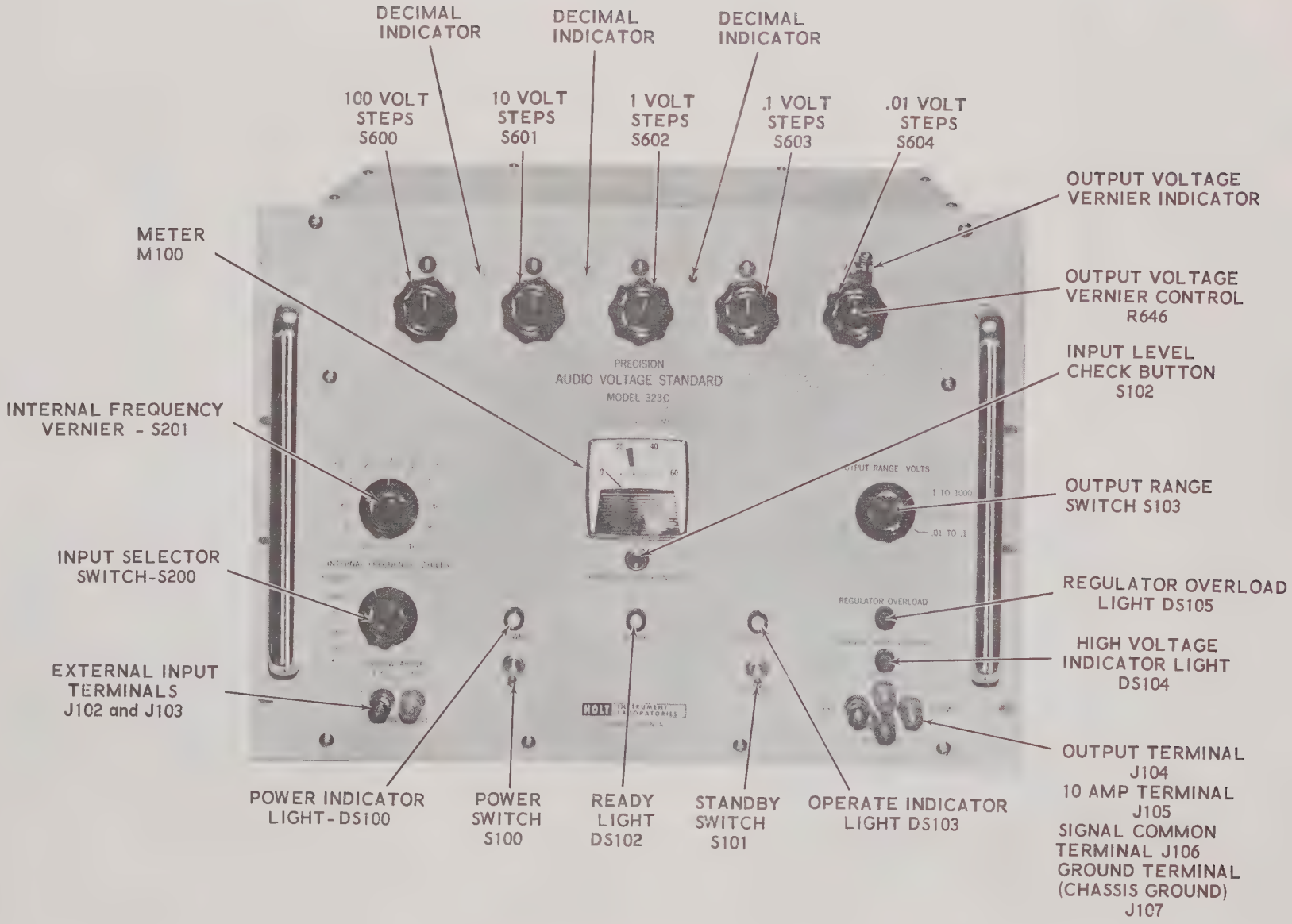


Figure 3. Operating Controls and Indicators

ternal controls and adjustments used in calibration and adjustment of the instrument are covered in the appropriate maintenance section.

a. Power Switch. In the POWER position, this switch applies power to the heaters and oven immediately and also to a 30 second time delay relay. At the completion of the time delay period, the plate voltage is automatically turned on. The unit is now in standby position ready for use.

NOTE

Although the unit is ready for use at the end of the 30 second time delay period, a warmup period of 30 minutes will allow the oven to reach a stabilized temperature resulting in improved accuracy and stability.

b. Power Indicator Light. When lit, indicates that power is applied to the unit.

c. Ready Light. When lit, indicates that the 30 second time delay is completed and plate power is applied to the unit. The unit is ready for operation.

d. Standby Switch. In the STANDBY position, this switch turns off the chopper and control amplifier and effectively shorts out the input signal at the input to the amplifier. All other circuits are warmed up with plate voltage applied. In the OPERATE position, the chopper and control amplifier are turned on and input signal is applied to the amplifier.

NOTE

When the unit is placed in standby operation, the output tubes V506 and V507 are held at a reduced power level, thereby increasing their life expectancy. It is always necessary to have the unit in STANDBY when the READY LIGHT is not lit. If this is not done, the +450 VDC protection circuit will operate and blow the +450V fuse. Replacing the fuse will restore the unit to complete operation.

e. Operate Indicator Light. When lit, indicates the standby switch is in the OPERATE position and the unit is operating.

f. Input Selector Switch. This seven position rotary switch enables the operator to select any one of five internal frequencies or to connect the amplifier to the external oscillator terminals. The internal frequencies are:

(1) 10,000 cps.

(2) 1,000 cps.

(3) 400 cps.

(4) 60 cps.

(5) 50 cps.

NOTE

The frequencies listed above are the stock frequencies supplied by the factory. Special frequencies are optional at extra cost.

Two positions are provided for connection to the external oscillator terminals. They are marked:

(6) BELOW 1 KC.

(7) ABOVE 1 KC.

Select the proper position depending on the frequency in use.

Two positions are provided so that the proper output transformer will be selected internally, since the output transformers have been especially designed for optimum performance above or below the 1 KC dividing point.

g. Internal Frequency Vernier. This eleven position rotary switch enables the operator to vary the internal oscillator frequency 10 percent above or 10 percent below the frequency selected by the Internal Selector Switch. The switch is arranged to allow changes in increments of 2 percent.

NOTE

The specified frequency range of Model 323C is 35 to 20,000 cycles per second. If a customer orders special frequencies for the input selector switch that are above 18,000 or below 40 cps, the ± 10% range of the Internal Frequency Vernier would require operation of the Model 323C outside its specified range.

h. Input Level Check Button. Pressing this button enables the operator to quickly determine if the input level to the amplifier is of sufficient amplitude to operate the unit. The input level is indicated on the front panel meter when the button is pressed. For proper operation, the needle should fall on the green calibrated section of the meter scale marked INPUT SET.

i. Output Range Switch. The three position Output Range Switch enables the operator to select the range of output voltages to be supplied and also

changes the decimal point on the digital readout indicator. The output voltage ranges are:

(1) 1 to 1,000 volts.

(2) .1 to 1 volt.

(3) .01 to .1 volt.

j. Output Voltage Controls. The five large knobs across the top of the panel, along with the center vernier knob on the top right hand control knob, make up the output voltage controls. Each of the main control knobs rotates a ten position switch and also changes the number on its corresponding digital readout window. The vernier dial controls a slide wire potentiometer and rotating dial indicator, a combination that makes available almost infinite resolution of the output voltage.

Selection of an output voltage is a two-step procedure:

(1) Select the output voltage range using the range switch. This will automatically set the decimal point on the readout.

(2) Select the desired output voltage by dialing the value with the five voltage selection knobs and the vernier while watching the readout indicators.

NOTE

BE SURE TO DIAL THE CORRECT OPERATING RANGE. Do not attempt to obtain .8 volt by setting the range switch to 1 to 1,000 volts and setting the selector switches to 000.8. The internal circuitry of the unit requires that voltage less than 1 volt and .1 volt be determined by changing the range switch and moving the decimal point.

NOTE

DO NOT OPERATE THE 323C WITH THE ATTENUATOR DIALED TO ZERO. Under this condition, a severe imbalance will occur in the regulator and return to balance when a required reading is dialed will require a longer time than normal. If zero output is required, place the unit in STANDBY position.

k. Regulator Overload Light. Under normal operating conditions, this light will remain off. The regulator overload light is on only when the control loop is not balanced and the output voltage is incorrect. This may occur when the output voltage or frequency is changed and the control amplifier and input regulator are correcting for the new conditions. When the correct output voltage is established, the light will go out. The light will also come on if the input voltage from the external oscillator drops below operating level. If the light stays on, some unbalance is indicated and must be corrected before using the unit.

l. High Voltage Indicator Light. This indicator light is lit whenever the output voltage is set above 100 volts. Voltages as high as 1,000 volts are available at the output terminals. This light serves as a warning not to touch the terminals while dangerous voltages are present.

m. Input Terminals. Whenever frequencies other than the five internal frequencies are to be used and external oscillator is connected to these terminals, use of a high quality oscillator (such as the HOLT Model 448) is recommended. Input level may be checked with the Input Level Check Button. See h. above.

n. Output Terminals. The output terminals consist of a group of four terminals, two black and two red. They are labeled on the panel as follows:

(1) GND - Black terminal connected to chassis ground.

(2) COMMON - Black terminal connected to the signal common in the unit. The signal common is floating within the unit. The only connection between signal common and chassis is the strap between the COMMON and GND terminals. With the strap removed, the common will float.

(3) OUTPUT - Red terminal to which is connected the calibrated output of the unit.

(4) 10 AMP - Red terminal which delivers 10 amperes at 1 volt. This is a nominal 1 volt output. If a calibrated 1 volt is required, use the OUTPUT terminal. Principal application of this terminal is in calibration of wattmeters or current devices using an accurate ammeter as a standard.

o. Meter.

(1) The front panel meter is connected directly to the output circuit and reads the output voltamperes. Full load on the unit is 30 voltamperes. At the higher frequencies, when using the high voltage output, the meter will show some load even with no connection to the unit. This reading is the voltampere load of the internal wiring and is normal.

(2) Pressing the input level check button under the meter switches the meter to the input circuit and monitors the input level. Input signal should read in the green calibration on the meter.

p. Fuses. Ten fuse holders and associated indicator lights are the only items on the front panel of the power supply unit. The fuses are assigned circuit symbols from F1001 to F1010 from left to right. The circuit protected by each is indicated on the schematics. The indicator light associated with each fuse will light if the fuse opens for any reason. Fuses should be replaced by same size

units so that short circuit protection of regulators is maintained.

The power supply is designed for operation on 115 or 230 volts, 50-60 cycles AC. If connections are changed from one voltage to the other (See Operating Instructions 2.1c), the size of the line fuse (F1001) must be changed as follows:

115v	230v
8 amp.	4 amp.

All other fuses are located in circuits which have the same current rating on both line voltages.

2.3 Applications

a. General. The primary function of the Model 323C is to act as a secondary standard to be used in the calibration of AC voltmeters. Because of its inherent characteristics as an accurately calibrated exceptionally stable source of AC voltage, and because of its wide frequency range and high output power capacity, the Model 323C is usable in a wide

Figure 4. Power Supply - Front Panel

range of calibration procedures. A few of the more common applications are detailed below.

b. Voltage Calibration.

(1) The wide range of output voltages permits the use of the Model 323C in the calibration of virtually every commercially available AC voltmeter. See figure 5. Since the voltage is variable and infinitely resolute, any and all full scale values may be checked as well as the linearity over any range. The wide frequency spectrum available offers the possibility of calibrating for a specific frequency or checking over a broad frequency range.

NOTE

In the application diagrams that follow, the location of the ground connection is shown schematically in some appropriate location. Actual location of the ground connection must be chosen with extreme care in each calibration system. Ground loops may introduce errors in calibration. Holt engineers will furnish an approved grounding circuit for each application upon request.

(2) Many companies have large quantities of meters that require accuracy checks at periodic intervals. The power capabilities of the Model 323C allow production testing of large numbers of instruments. This is accomplished by connecting all the meters in parallel across the output terminals. See figure 6. The best procedure is to set the Model 323C to a cardinal point voltage plus the tolerance; check all the meters to see how they read above the cardinal point; reject all those reading below. Reset the Model 323C to the cardinal point minus the tolerance; check all the meters to see they read below the cardinal point; reject all those reading above. Thus, the operator can select the instruments requiring calibration without the need to make any quantitative readings of the meters.

(3) Accuracies of calibration approaching those of DC measurements are possible by the use of a transfer standard, such as the HOLT TV1, used in conjunction with the Model 323C. Figure 7 illustrates a block diagram of the test setup using the Model 323C with a transfer standard. The Holt Thermal Transfer Voltmeter is essentially a device for comparing DC to an equivalent RMS value of AC. Its AC terminals are connected to the AC

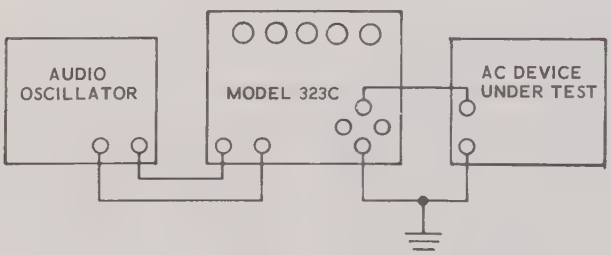


Figure 5. Voltage Calibration

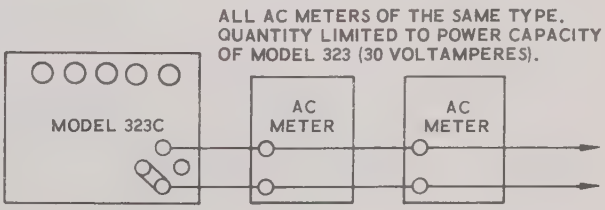

ALL AC METERS OF THE SAME TYPE. QUANTITY LIMITED TO POWER CAPACITY OF MODEL 323 (30 VOLTAMPERES).
MODEL 323C
AC METER
AC METER

Figure 6. Production Voltage Calibration

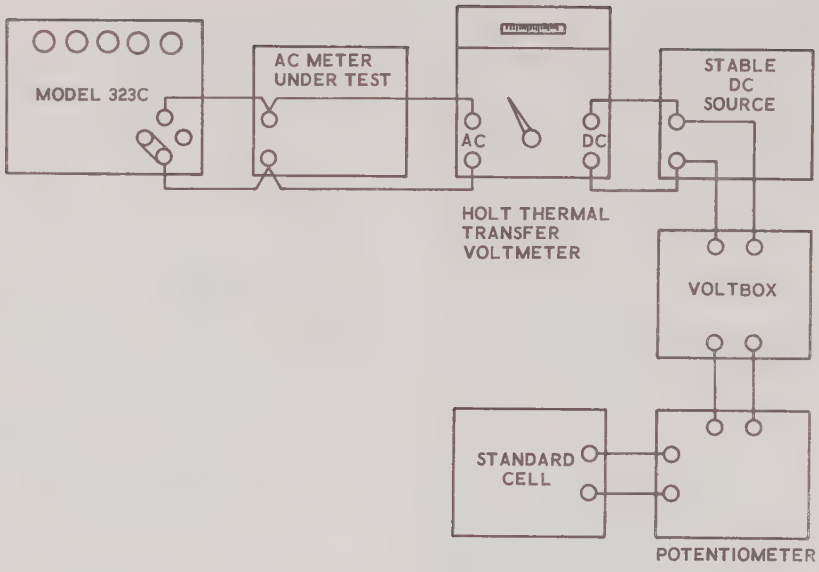


Figure 7. Typical Test Set-up for Transfer Standard

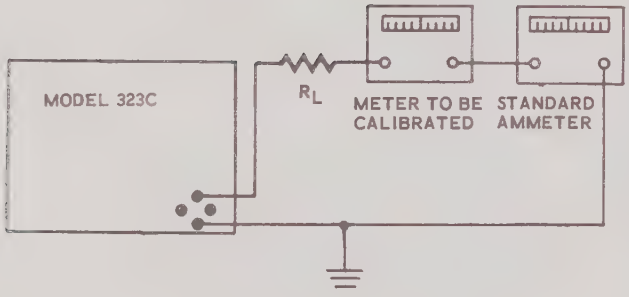


Figure 8. Ammeter Calibration

meter under test which is supplied from the Model 323C. (In this arrangement, the stable output and infinite resolution of the output voltage of the 323C are very important.) Its DC terminals are connected to a stable DC supply. The accurate calibration of the DC supply is secured by comparison with the output of a standard cell through a potentiometer and a voltbox. By using the transfer standard to balance the AC calibrating voltage against the very accurately calibrated DC voltage, the meter under test can be calibrated to accuracies of .02% over the frequency range of the Model 323C.

c. Ammeter Calibration.

(1) The Model 323C may be used as a stable source of alternating current for the calibration of

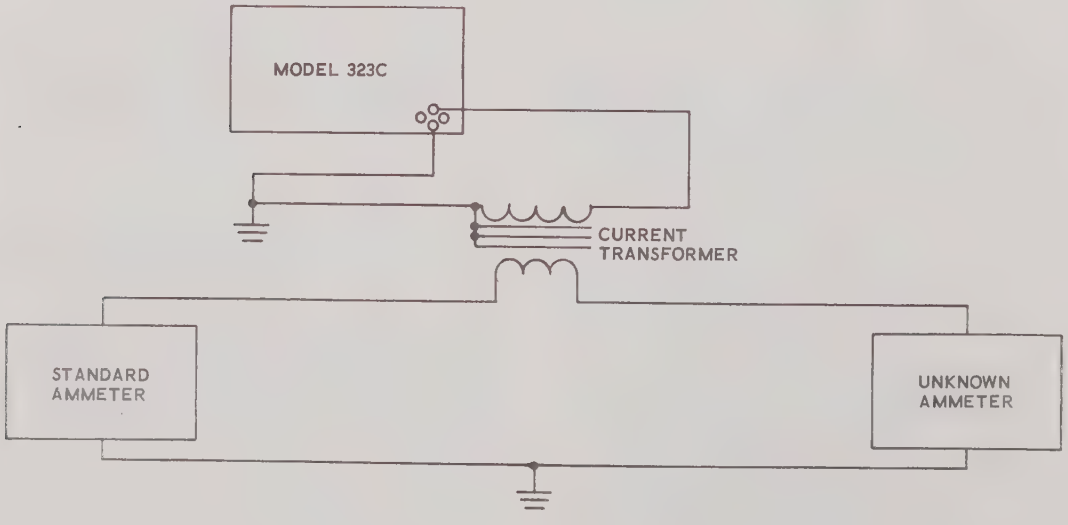


Figure 9. Use of Current Transformer

AC ammeters. The ammeter under test and a standard ammeter should be connected in series with a suitable current limiting resistor across the output terminals of the Model 323C. See figure 8. If the limiting resistor R_L is properly chosen with respect to the resistance of the standard meter R_S and the meter under test R_X, the output dials of the Model 323C will read directly in amperes or milliamperes with a reasonable degree of accuracy. Choose the value of R_L as follows:

Full scale current of meter	
3 amps	R_L equals 1 - (R_S+R_X)
1 amp	R_L equals 10 - (R_S+R_X)
100 ma.	R_L equals 100 - (R_S+R_X)
10 ma.	R_L equals 1000 - (R_S+R_X)
1 ma.	R_L equals 10K - (R_S+R_X)

NOTE

If the meter to be calibrated is a passive meter (i.e. not connected to the power line) use the circuit illustrated in figure 8. If the meter to be calibrated is connected to the power line, the ground point must be carefully chosen to eliminate current leakage paths. One way to check for leakage currents is to insert a fixed resistor in the ground lead and measure the voltage drop across it.

(2) An isolating current transformer connected across the output of the Model 323C will permit both ammeters to be grounded and also permit the calibrating current to be stepped up in proportion to the current transformer ratio. See figure 9 for the recommended circuit. Load must not exceed the rated 30 voltamperes. Holt Instrument Laboratories can recommend a transformer, or set of transformers, to fit the particular ranges of current, frequency and burden required.

d. Wattmeter Calibration.

(1) The Model 323C has been provided with an auxiliary output terminal connected to the 1 volt tap on the output transformer capable of supplying up to 10 amperes. This terminal may be used as a source of current for the calibration of wattmeters. See figure 10 for the recommended connections. The resistor R is a carbon pile or wire wound rheostat used to set the current coils of the wattmeters. (It is sometimes desirable to make R from a 100 ohm rheostat in parallel with a 2 or 3 ohm rheostat to obtain better resolution.) At low frequencies (below 400 cycles), the standard wattmeter may be replaced by a standard ammeter and a standard voltmeter. Calibration by this method will be at essentially unity power factor.

NOTE

To check the phase angle, connect an oscilloscope with vertical deflection to point A and horizontal deflection to point B.

(2) Wattmeters and watthourmeters with current coils rated up to 10 amperes may be checked by the above method. Care must be taken to see that the total power drain does not exceed 30 watts.

e. Frequency Response Measurements. The ability to rapidly select a wide range of calibrated voltages at five different frequencies (or at any frequency if an external oscillator is used) make the Model 323C useful for checking the frequency response of amplifiers. Because of the high output power capability of the unit and the fact that the Model 323C is virtually insensitive to reactive loads it is highly useful in checking the frequency response of filters and transformers.

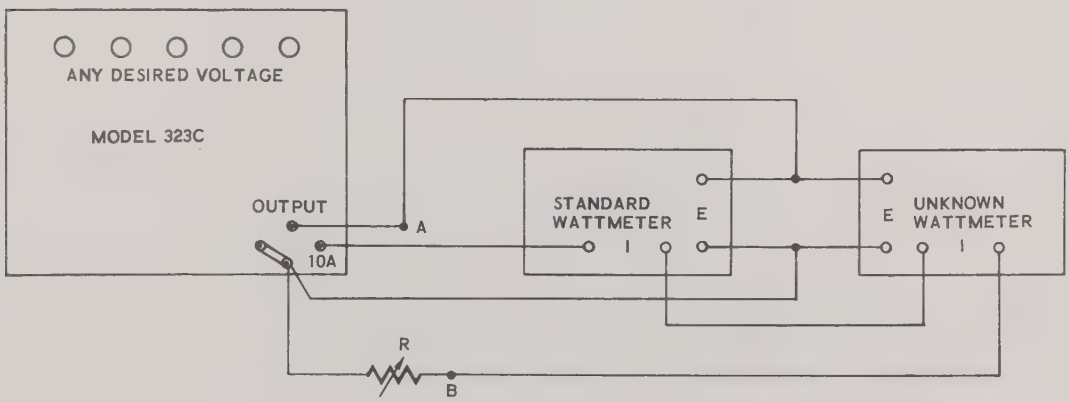


Figure 10. Wattmeter Calibration

SECTION 3

THEORY OF OPERATION

3.1 General Theory

a. The Model 323C is made up of two chassis units. The first, Power Supply Model 323 PS/1, contains all of the power supplies, regulators and the reference pack. The second chassis houses the amplifier, input regulator, voltage selectors, and precision output transformers. Separation of the chassis provides a maximum of isolation of the 60 cycle power circuits from the low level signal circuits.

b. Power Supply Chassis.

(1) General. The power supply chassis can be divided into three basic circuits. Basic operation of these circuits is discussed below. Refer to the block diagram of the power supply chassis (figure 11).

(2) Filament Supply. The filament transformer powers the AC filament circuits of the power amplifier tubes. In addition, the transformer

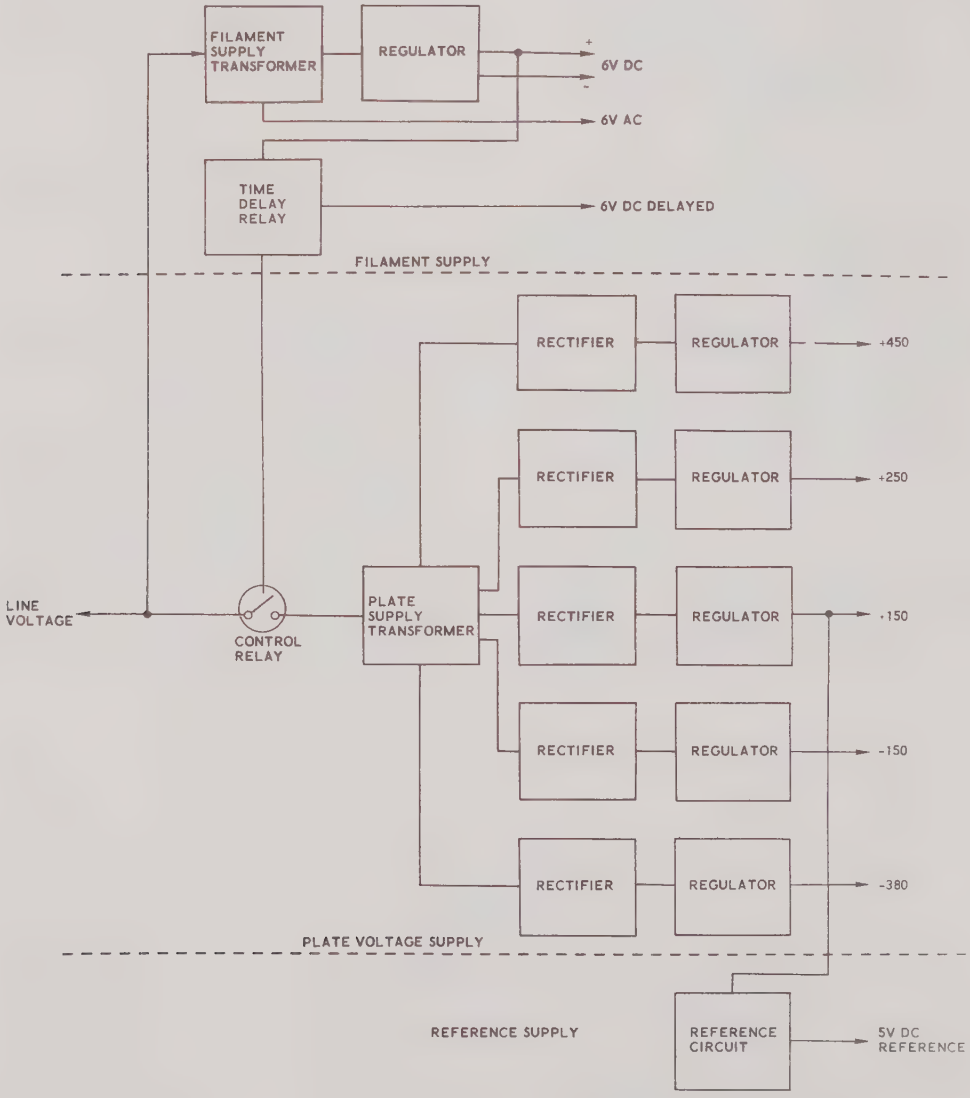


Figure 11. Power Supply - Block Diagram

supplies a rectifier and regulator which provides a regulated DC voltage for the filaments of all other tubes in the unit. A time delay relay also operates from the regulated supply. Its function is to delay the plate supply voltage for 30 seconds to allow the tubes to reach operating temperature. The time delay relay also supplies a 6 volt delayed line which powers certain control relays.

(3) Plate Voltage Supply. The plate supply transformer is connected to its supply voltage through a relay controlled by a 30 second time delay relay. This allows the heaters to warm up before plate voltage is applied. The plate transformer supplies power to five rectifier and regulator circuits. All rectifiers and regulators are solid state circuits.

(4) Reference Circuit. The reference circuit is powered from the regulated +150 volt supply. Output from the reference circuit is a very stable DC voltage used as the reference voltage throughout the unit. Heart of the reference circuit is a temperature compensated zener diode which is factory selected and aged to insure its stability within close limits.

c. Regulator Chassis.

(1) General. The theory of operation of the audio voltage standard can best be described by referring to the block diagram, figure 12. The regulator circuit is made up of a power amplifier and a control loop. Any error in the output of the power amplifier is detected by an error circuit and corrected by the input regulator circuit. Each of these three circuits are discussed below.

(2) Power Amplifier. The input selector switch connects the amplifier input to an external oscillator or to the internal oscillator. The internal oscillator allows a choice of five pre-selected frequencies. The input signal is applied across the 300 ohm input impedance of the input regulator. The signal fed from the input regulator is controlled by a DC correction signal from the control amplifier. From the input regulator, the input signal is applied to an input attenuator and then to the power amplifier. A push button switch enables the operator to monitor input level or output voltamperes on a front panel meter. The power amplifier output is delivered to a set of tapped output transformers. The output selector switches select the proper tap

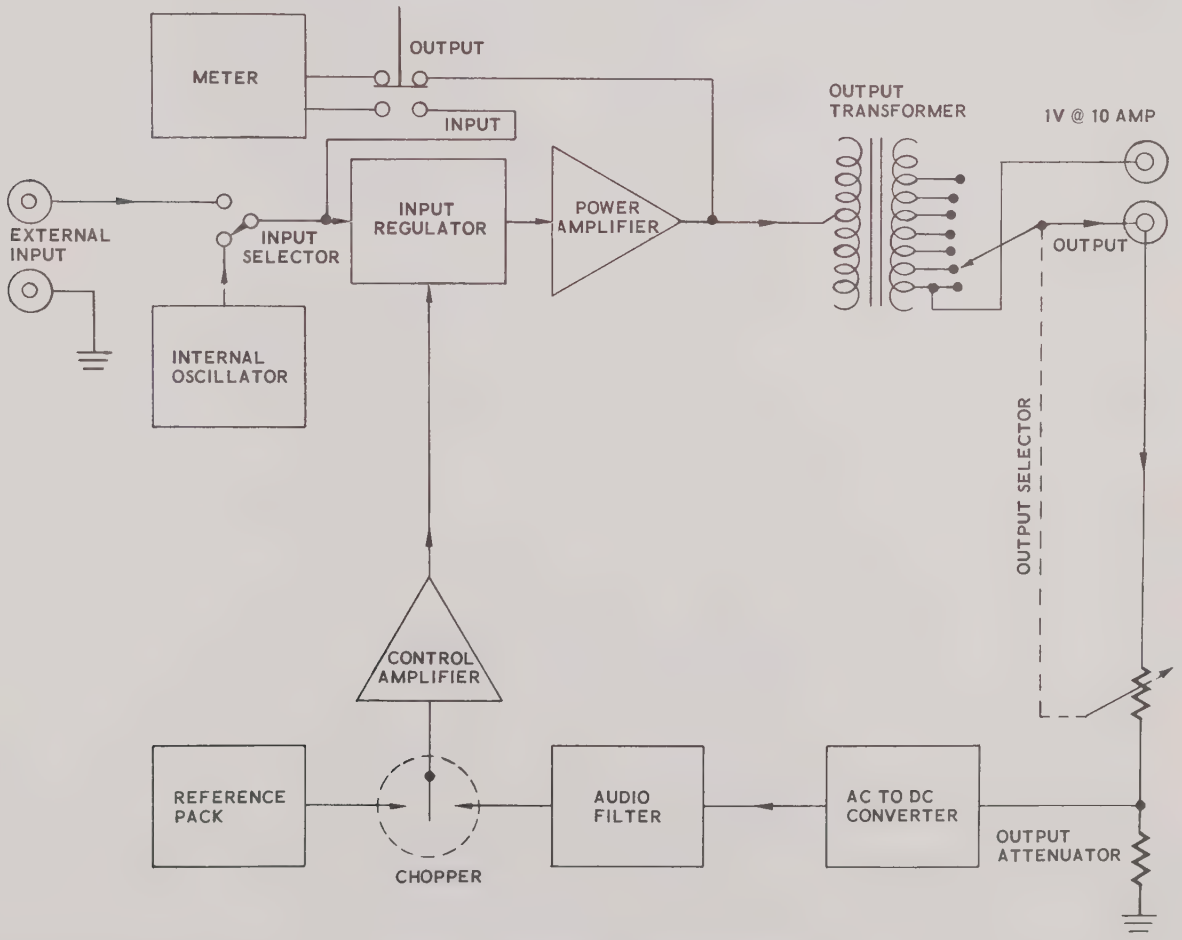


Figure 12. Regulator - Block Diagram

to deliver the required voltage output and also select the proper voltage divider resistor to give an output voltage of one volt at the input to the AC to DC converter.

(3) Error Circuit. The voltage selector is connected across the output terminals and its resistor values are selected to give one volt of input to the AC to DC converter when the output voltage is correct. The variations of voltage at the input to the converter stage will always be proportional to the variations in the output voltage. The function of the error circuit and the control amplifier is to keep the voltage at the divider tap equal to one volt, and thus set the output voltage to the correct value. The AC to DC converter is an averaging device whose DC output is proportional to its AC input. This DC output is then filtered by an M derived low pass audio filter and applied to one contact of a 60 cycle chopper. If the output voltage as set by the selector switch is correct, the DC level to the chopper will be five volts. The chopper compares this five volt output signal with a very exact voltage reference signal from the reference pack. Any difference between the two signals must be due to an incorrect output voltage and results in an error signal from the chopper circuit. This error signal is a very low level, 60 cycle signal which is fed to the control amplifier.

(4) Control Amplifier and Input Regulator. The error signal fed to the control amplifier is a 60 cycle voltage whose level is proportional to the error in the output voltage. It is essentially a square wave. The control amplifier raises the level of this signal, feeds it to a phase inverter and then to a synchronous demodulator (part of the chopper). The DC output of the demodulator is filtered by an RC combination whose time constant is controlled by the recovery module during overload. The resulting DC varies in amplitude and polarity in proportion to the error in the output voltage. This DC signal is amplified by a DC amplifier and used to control the input regulator. The input regulator, in turn, will vary the input audio signal level in such a manner as to reduce the error signal to zero.

3.2 Basic Circuit Theory

The paragraphs that follow will each be devoted to a discussion of the operating theory of one of the basic circuits that make up the Model 323C. Each circuit discussion will cover one schematic diagram so far as possible, although the interconnection of the circuits will require reference to more than one schematic in some cases. All schematics will be found at the end of the text. Reference will be made by schematic title, rather than by figure number. Refer to the block diagrams (figs. 11 and 12) to better understand the position of each circuit in the action of the Model 323C.

3.3 Internal Oscillator

a. The basic circuitry of the internal oscillator is shown in block diagram form in figure 13. Oscillation is accomplished by feeding back the output signal from the main amplifier through a "bridge tee" RC circuit. This RC circuit determines the frequency of oscillation. Some output signal is also applied across a thermistor bridge. The DC output of the thermistor bridge is amplified by the AGC amplifier and fed back to the main amplifier to stabilize the output level. Negative feedback is employed across both amplifiers to stabilize their operation.

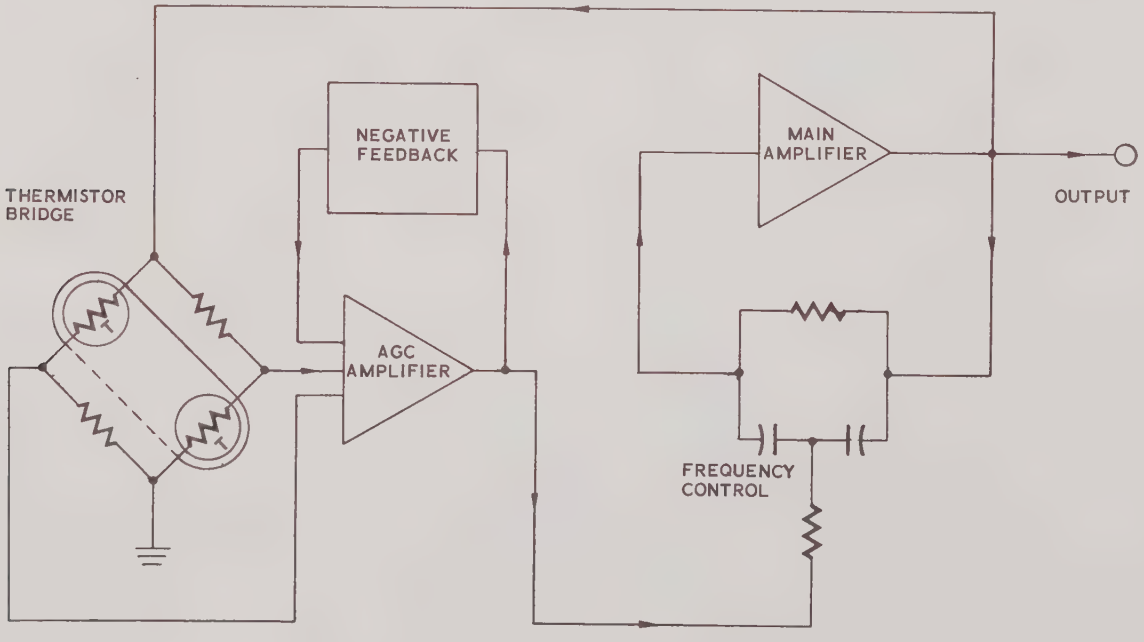


Figure 13. Internal Oscillator - Block Diagram

b. Refer to the schematic INTERNAL OSCILLATOR. The main amplifier consists of V202, V203, and V204 connected as a four stage direct coupled amplifier. The AGC amplifier consists of V200 and V201 also direct coupled. Both amplifiers employ negative feedback to stabilize their operation. Oscillation is secured by feeding back an output signal from the cathode of V204 through the AGC amplifier to V202. This signal is regenerative and of sufficient amplitude to cause oscillation at the fundamental frequency determined by the band pass characteristics of the bridge tee.

c. The output frequency is controlled by two switches, the input selector switch and the internal frequency vernier. The input selector switch, S200, selects the proper values of the bridge tee for operation at the five desired frequencies. The internal frequency vernier, S201, switches a small value of capacity across the capacitors in the bridge tee. The value of capacity in each position is sufficient to change the frequency by increments of two percent. High precision, stable components are used in the bridge tee to insure accurate and stable frequency control.

d. The thermistor bridge controls the amplitude of the output signal. Output from the cathode of V204 is applied across the thermistor bridge. The inputs to the AGC amplifier are taken from the bridge, each side of the bridge supplying one grid of V200. When the amplitude of the output voltage rises, the thermistors heat. This decreases the proportional amount of regenerative feedback supplied by the AGC amplifier, and the net result is a decrease in output. This combination functions to keep the output at a constant level of ten volts at the cathode of V204.

e. The thermistor bridge is temperature sensitive and requires an oven for stable operation. The oven temperature is maintained at 55 degrees C. (± 1 degree) by a thermostat and transistor control circuit. Transistors Q200 and Q201 act as a switch controlled by the thermostat and operate the oven heater. The oven, switch circuit, and heaters of all tubes in the oscillator are operated from the six volt regulated DC supply, thereby minimizing the 60 cycle component in the oscillator output.

3.4 Power Amplifier

a. The power amplifier consists of four sections: a high gain pre-amplifier, a phase inverter, a driver amplifier, and the power output stage. See figure 14.

b. The pre-amplifier consists of V501A and V501B and V502A. These tubes make up a frequency compensated, three stage, single-ended amplifier. This amplifier is designed for high gain and low noise. Feedback of approximately 20 db is fed from the cathode of V502A to the cathode of V501A.

c. The phase inverter (V502B) is a single stage, split load type circuit. It is inherently a self-balancing circuit, although a balance control (R514) is provided in the plate circuit to insure balance of the output signals and minimize even order harmonics.

d. The driver amplifier consists of three stages (V503, V504, and V505) in push-pull. Each stage is frequency compensated and capable of amplifying very large signals. Additional signal swing is made possible by feeding the plates of V504 and V505 from the output screens, thus introducing a small amount of regenerative feedback.

e. The final amplifier consists of V506 and V507, a pair of KT 88 tubes in push-pull. The final amplifier is assembled on a metal chassis for improved heat dissipation. The final tubes are split loaded and operated as class AB1 amplifiers. This combination provides the best possible power output at the lowest possible distortion.

Connected with the cathode windings of the output transformer (T100) is the primary of a small current sensing transformer (T101). The secondary of this

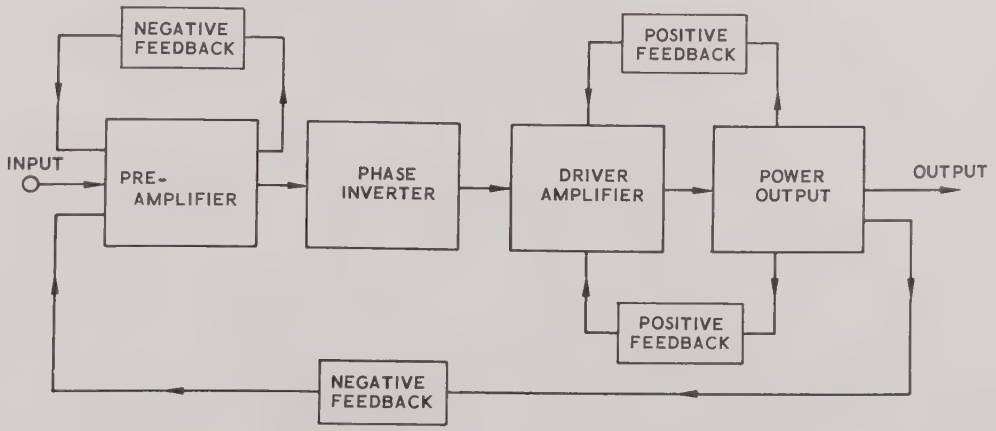


Figure 14. Power Amplifier - Block Diagram

transformer provides an output voltage proportional to the final amplifier signal current. This voltage is used to monitor the output voltamperes and to control a bias adjust circuit described in paragraph f. below. A pair of relay contacts connected in the center tap of the transformer secondary are opened when the unit is switched to STANDBY, placing resistor R101 in the cathode circuit, thus holding the output tubes at a reduced power level during standby.

Taps 1 and 2 on the output transformer provide additional feedback around the complete amplifier. Feedback is returned to the cathode of the input pre-amplifier.

f. The quiescent currents of V506 and V507 are adjusted by the output bias controls (R554 and R555). A frequency selective network consisting of C520, C521, C522, R545, R546, and R547 passes a signal proportional to load from the current sensing transformer (T101) at output frequencies below 200 cps and above 10 KC only. These signals are rectified and cause Q500 to conduct. Conduction of Q500 causes the output bias voltage to go more positive, which increases the quiescent current in V506 and V507 and minimizes the full load distortion.

3.5 Voltage Switching and Attenuator Circuit

The voltage output switching and the attenuator system used to sense the output voltage to establish correct values are, in a sense, the heart of the Model 323C. Use of high quality, stable, factory selected components is essential if high precision output calibration is to be maintained. The schematic diagram VOLTAGE SWITCHING AND ATTENUATOR can be divided into five sections as described below.

a. Output Voltage Selection (1 to 1000 volts). Voltage selection in the Model 323C is accomplished by switching to the proper output transformer secondary tap. Two secondaries are provided on the output transformer (T100). They are connected so their outputs are additive. The secondaries are tapped to provide 1 and 10 volt output steps respectively. By selecting the proper voltage taps, increments of 1 are available from 1 volt to 99 volts. Note that no tap is provided for less than one volt. For voltages above 99 volts, the 90 volt output transformer winding drives either of two secondary step-up transformers (T102 and T600). These step-up transformers have a secondary tapped in 100 volt increments from 100 volts up to and including 900 volts. For the best possible frequency characteristics, two high voltage transformers are employed. The first (T102) is used at frequencies below 1 kilocycle and the second (T600) above 1 kilocycle. Switching these transformers is necessary only above 99 volts and is accomplished by the Input Selector Switch. Switching is accomplished automatically (through relay K600) when selecting an internal frequency. When changing to a frequency above 1 KC from an external source, the switch must be properly positioned. The output of the high voltage transformers is additive with that of the normal output transformer.

b. Output Voltage Selection (below 1 volt). When

NOTE

The 10 and 100 volt switches are not used when operating below 1 volt. These dials are disconnected electrically and by mechanical linkage, zero's appear in the indicator windows.

the range selector (S103) is positioned anywhere below the 1 to 1000 volt range, the level in the output transformer does not change. Instead, a precision ratio transformer (T601) is driven from the 1 to 10 volt taps. Two ratios are available: 10:1 and 100:1. Choice of ratios is determined by the Range Selector Switch.

c. Output Attenuator. The output attenuator is a precision resistive divider which is changed in value by the voltage selector switches (S600 through S604). Resistances are selected in such a manner that a constant 1 volt level is maintained at the input to the AC to DC converter AS LONG AS THE OUTPUT IS CORRECT. Variations in output terminal voltage are reflected as variations in the 1 volt level and appear at the input to the converter. The primary requisite of the output attenuator circuit is that it be precise in ratio and long term stability. Inspection of the attenuator and voltage selector circuits will disclose additional switch contacts required to provide the logic switching over the entire voltage range of the unit.

d. Input Attenuator. When operating in the .1 volt (S603A) positions at less than 10 volt output, an input attenuator is used ahead of the power amplifier. This divides the voltage input to the power amplifier to compensate for a change in output transformer taps to reduce the voltage variation required by the control amplifier-input regulator combination. The input attenuator is disconnected from the circuit when the .1 volt (S603A) dial is on zero, and when the 100 volt (S600B) and 10 volt (S601B) dials are not on zero.

e. Frequency Compensation. In order to insure that the output is flat across the entire operating frequency range, the output attenuator is compensated during the factory calibration procedure. Since compensation will differ slightly from one model to the next, the values of capacity shown on the schematic are nominal values.

CAUTION

Each Model 323C is individually compensated at the factory for the distributed capacity of its own wiring and components. DO NOT CHANGE THE POSITION OF THE WIRING OR OF THE COMPONENTS IN THIS SECTION. Any movement of parts or wiring will necessitate recompensation of the output attenuator.

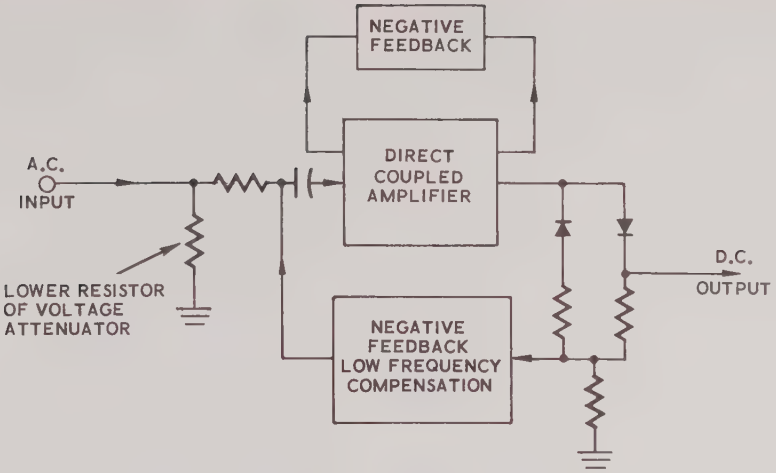


Figure 15. AC/DC Converter - Block Diagram

3.6 AC to DC Converter

a. The input to the converter stage appears across a network of resistors R700, R701, and R704. This combination actually makes up the lower resistor of the output attenuator circuit. See figure 15. Resistor R704 is adjustable and is used to calibrate the output attenuator. High frequency compensation for the converter is supplied by the variable capacitor (C709). The nominal one volt input to the converter appears across the resistance network.

b. The direct coupled amplifier consisting of V701, V702, and V703 is frequency compensated and employs DC feedback to stabilize its operation. The output of the amplifier drives a cathode follower V704. DC feedback is taken from the output of the cathode follower and applied to the amplifier input grid. The DC output from the converter is taken from the cathode follower through diode (CR701). An AC feedback loop is also fed from the same cathode follower through diodes (CR701 and CR700). This AC feedback is returned to the converter input through an RC network chosen to supply low frequency compensation. Resistor (R721) is the low frequency compensation control.

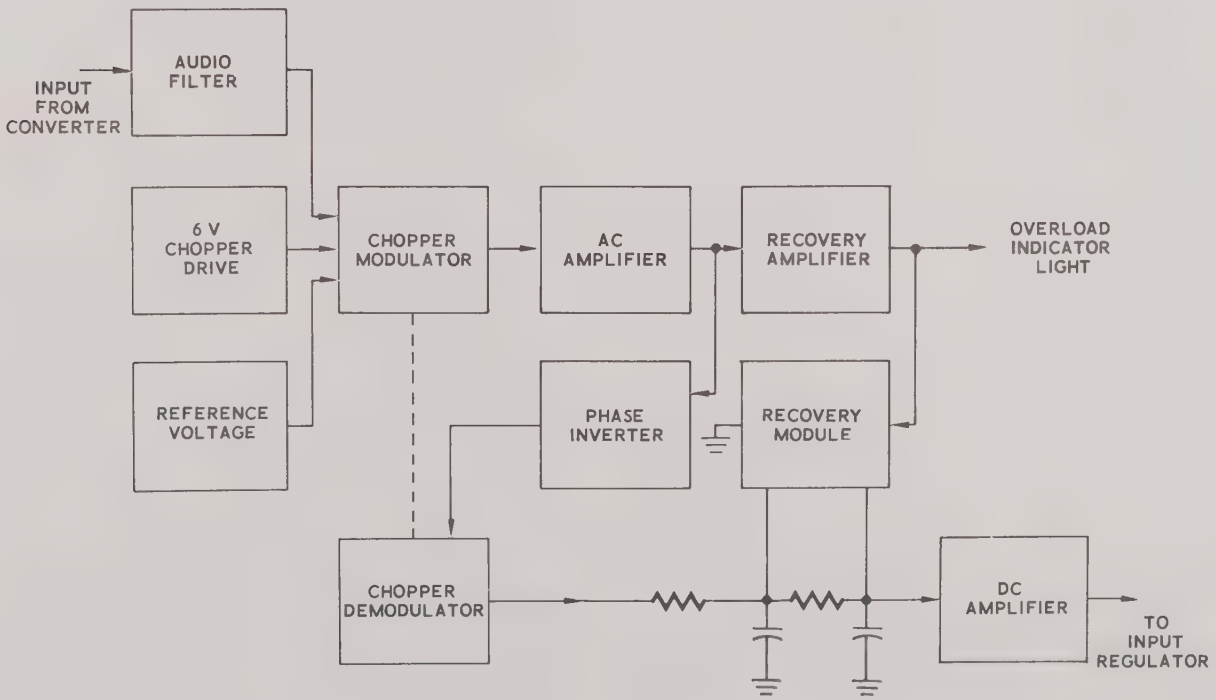


Figure 16. Control Amplifier - Block Diagram

c. The output of the converter stage is a positive half wave of voltage taken across R729 and R728. Since this voltage is the result of amplifying and rectifying the one volt signal from the attenuator, the resulting DC voltage is proportional to the output voltage at the terminals of the Model 323C.

3.7 Control Amplifier

The schematic diagram titled CONTROL AMPLIFIER includes the diagrams of the audio filter and chopper circuits as well as the control amplifier itself. See figure 16 for a block diagram of the control amplifier and chopper circuit.

a. Audio Filter. The rectified positive half waves of voltage from the AC to DC converter are fed to the audio filter. This M derived low pass filter has a cutoff value of about 20 cycles and falls off sharply above 20 cycles. Response through the filter is from DC to approximately 20 cycles per second. The output from the filter is a nominal 5 volts positive DC voltage and is applied to pin 1 of the chopper.

b. Chopper Circuit. The chopper is a two pole device. One pole, a make-before-break switch, is used as a modulator; the other pole, a break-before-make switch, is used as a synchronous demodulator. The chopper is a 60 cycle device driven from a 6 volt AC winding on T1002. The function of the modulator section is to compare the output of the audio filter with the positive five volt DC reference voltage. Since both are five volt positive levels, there will be no output from the chopper modulator unless one level varies. The reference level is fixed so error signal will appear only when the output of the audio filter changes and this level is proportional to the output voltage at the terminals. The 60 cycle signal from the modulator will, therefore, serve as an indication of the error in the output terminal voltage. The amplitude of the error signal will indicate the amount of error and the phase will indicate the error above or below the calibrated output voltage.

The second section of the chopper, the demodulator, is connected following the phase inverter in the control amplifier. Its function is to convert the amplified square wave error signal to a DC signal that varies in amplitude and polarity in proportion to the amplitude and phase of the error signal.

c. Control Amplifier. The control amplifier consists of three basic sections; an AC amplifier and phase inverter, the recovery amplifier and recovery module, and a DC amplifier.

(1) AC Amplifier. The low level 60 cycle error signal from the chopper modulator is fed to the input grid of the AC amplifier. This amplifier consists of a four-stage amplifier (V401, V402A and B, V404A) followed by the phase inverter (V404B). The first three stages provide about 75 db gain. A feedback loop through C419 provides 10 db feedback to improve stability across these three stages. Three diodes (CR401, 2, 3) located in the grid circuits have no effect on low level signals, but provide an easy path for discharging the coupling condensers in the event of large signals thus preventing blocking of the amplifiers. Resistor R430 is an adjustable control for servicing purposes. In normal operation it remains in the maximum signal position. It can be turned down to allow testing of the AC amplifier without the correction loop functioning. V404A provides an additional 20 db gain into the phase inverter. The output of the phase inverter is applied to the chopper demodulator. This output is a square wave which, under maximum error conditions, will not exceed 50 volts peak-to-peak.

(2) Recovery Amplifier. An error signal from the plate of V402A is fed into the grid of V403A, the input of the recovery amplifier. This input signal is a square wave that may approach 25 volts peak-to-peak under maximum error conditions. Output is taken from the cathode of V403A and rectified by diode CR404. The resulting DC voltage is coupled to transistors Q401 and Q402 which act as a DC amplifier. Capacitor C418 is employed in a circuit with a relatively long time constant, thus preventing rapid changes in the input level to the DC amplifier. Collector current from Q402 flows through the recovery module between terminals 2 and 4. This variation in current flow results in a change in resistance between terminals 1 and 3 on the module. The resistance will vary between 1000 ohms and infinity as the current flow varies from maximum to zero. The output of this transistor amplifier is also used to control the overload indicating light through an additional two stage solid state amplifier. (See Meter Schematic.) With maximum error signal, the voltage at the collector of Q402 will be approximately five volts and the lamp will light. When the error is reduced to zero, the collector voltage will drop to zero and the lamp will go out.

(3) DC Amplifier. The output of the chopper demodulator is a DC voltage which varies in proportion to the error signal. This DC voltage is filtered by an RC network containing C423 and C424. These two capacitors and their associated resistors have a long time constant which would limit the response of the control circuit to rapid variations in error signal. In order to provide a variable time constant in this filter, the recovery module is bridged across R443. Since the resistance of the recovery module varies with error voltage (through the recovery amplifier), the time constant of the filter can also be varied in proportion to the error signal. The resulting DC control voltage is applied to the grid of V403B, a cathode follower, and then to Q403, an emitter follower. The DC voltage at pin 13 of P400 is approximately + 2.5 volts with no error signal applied. This output voltage from the emitter of Q403 is used to control the action of the input regulator and thus control the output voltage. Resistor R448, in the emitter circuit, is adjusted with 1 volt input at J102 and J103. Set R448 to provide 0 voltage on the grid of V403B.

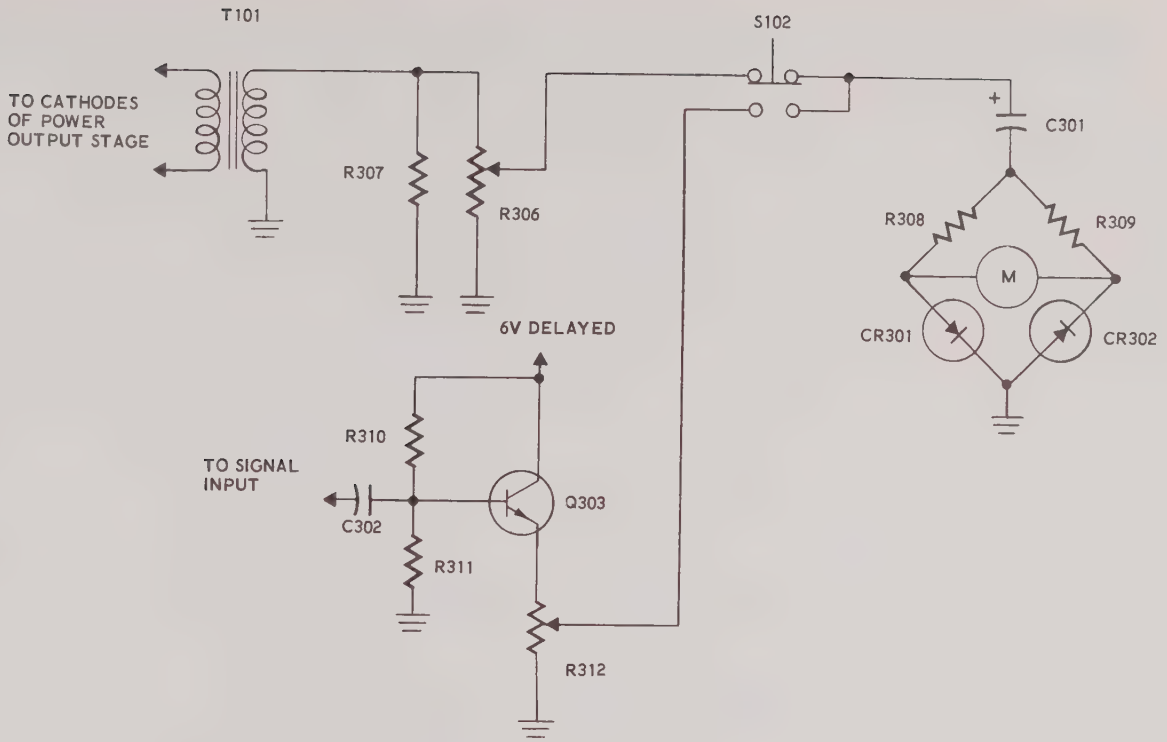


Figure 17. Meter Circuit

3.8 Input Regulator

The function of the input regulator is to control the input signal in such a manner as to keep the error signal voltage at zero. The DC error voltage from the DC amplifier is supplied to terminal 1. The output signal voltage from terminal 5 will vary in level as controlled by this DC error voltage.

3.9 Meter Circuit

The METER schematic diagram illustrates the major portion of the circuits of two indicating devices, the front panel meter and the overload indicator light. See figure 17 for simplified diagram of the meter circuit.

a. The meter is connected across a rectifier bridge since the input and output to be measured are AC signals. With the switch (S102) INPUT LEVEL CHECK BUTTON in the UP position, the meter is connected to the arm of a load calibration potentiometer (R306). This control is connected across the secondary of transformer (T101). This is the transformer whose primary is in the cathode circuit of the power output tubes. The voltage from this transformer is proportional to the output current. Since the voltage across the output transformer primary is essentially constant, the meter can be calibrated in output voltamperes. The calibration potentiometer (R306) is adjusted to provide a 30 VA reading at 1 KC with an output voltage of 10 volts and a resistive load of 3.3 ohms.

With the button depressed (switch in the lower position), the meter is connected to the output of a transistor isolation amplifier. This emitter follower (Q303) isolates the meter circuit from the input to prevent loading of the input circuit. An adjustable resistor (R312) in the emitter circuit serves as a calibration adjustment. It is adjusted by applying 1 volt at 1 KC to the input terminals and adjusting R312 (with button depressed) until the meter needle reads at the lower edge of the green scale section. The input to the isolation amplifier is taken from the input circuit just ahead of the input regulator and thus the meter reads input regardless of whether an internal or external oscillator is used.

b. The regulator overload light circuit is controlled from the error signal. The error signal from pin 1 of Plug (P300) is a DC voltage that is applied across a voltage divider to the base of transistor (Q301). This transistor and the one following (Q302) make up a DC amplifier. This amplifier is powered from the six volt DC source and collector current from Q302 operates the overload lamp when error voltage is sufficiently high.

3.10 +150V Regulator and Precision Reference

a. General. All of the power supplies used on the Model 323C are highly regulated, solid state circuits employing the same basic series type regulator circuitry. Over the specified temperature range of the instrument, these supplies have ex-

cellent stability and extremely low peak-to-peak ripple. A block diagram of a typical regulator circuit is shown in figure 18 and described below.

The output of the regulated supply is sampled by a voltage divider consisting of R1 and R2. This output sample is applied to a differential amplifier. The symmetrical arrangement of a differential amplifier tends to make it self-compensating for temperature variations. This compensating effect is further improved by connecting the differential amplifier transistors together with a common heat sink. The differential amplifier compares the output sample to the voltage across the zener reference diode. Any error or drift in the output voltage is amplified by an error amplifier, fed to a control amplifier and used to control the action of the series regulator. The regulator, in turn, corrects the output voltage. The constant current source for the control amplifier is obtained from the regulator circuit through a zener diode arrangement. All of the regulators in the Model 323C operate on the principles described above. Each stage may consist of one or several transistors depending on the voltage and current requirements of the circuit and upon the regulation required.

b. +150 Volt Regulator. A secondary winding (terminals 11 and 12) of power transformer (T1002) supplies 148 VAC to a conventional bridge rectifier with RC filters.

The regulator output is sensed between resistors R1109 and R1110 and applied to the input of the differential amplifier consisting of transistors Q1103 and Q1104. The output voltage is compared to the zener diode (CR1105) voltage and the resultant error voltage is applied to the base of error amplifier transistor (Q1102). The control amplifier consists of transistor (Q1101). Transistor Q1101

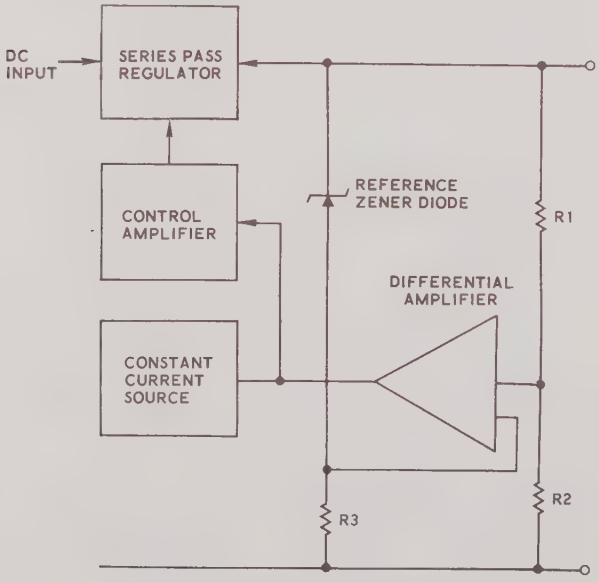


Figure 18. Power Supply Regulator - Block Diagram

operates from a constant current source established by diode CR1106 and resistor R1103. Q1002 and Q1003 are the series pass regulator transistors. Both transistors Q1002 and Q1003 handle large amounts of current and require substantial heat sinks. Both are located on the rear panel heat sink assembly and are not part of the regulator circuit board. A test point TP1101 is located on the top of the circuit board and provides a quick check on regulator output (+150 VDC).

c. Precision Reference Circuit. The circuit of the precision reference is located on the same schematic as the +150 volt regulator. The reference operates from the +150 VDC regulated supply. Heart of the reference supply is the zener diode CR1109. This diode is carefully selected and aged over a ninety day period to insure its long term stability.

One peculiarity of some zener diodes is the fact that they can be temperature compensated to give minimum variations with temperature over a given range of ambient temperature by setting their current to an experimentally chosen valve. The function of resistors R1112 and R1113 is to set the current through the zener to this ideal value for instrument operation in the range 20 to 45° C. ambient. The optimum value of the current must be determined experimentally in Holt Laboratories. Resistor R1113 is factory adjusted for this value and its adjustment should not be changed in the field.

Calibration of the exact reference voltage is secured by factory selection of the resistors R1114 and R1115.

3.11 +250V and +450V Regulators

a. +250V Regulator. This power supply circuit is supplied from a 243 VAC secondary (terminals 9 and 10) on the power transformer T1002. The rectifier circuit and regulator circuit are very similar to those described in paragraph 3.10 a. and b. The only major change in the regulator circuit is the use of transistors Q1011, Q1012, Q1013 and Q1014 connected in series to act as the series regulator in the supply. This type of connection is necessary to keep the voltage across each individual transistor within safe operating limits. A test point TP1201 is located on the top of the circuit board to provide a quick check on regulator output (+250 VDC).

b. +450V Regulator. This power supply circuit is supplied from a 443V AC secondary (terminals 7 and 8) on the power transformer T1002. The rectifier circuit is a bridge type with series diodes in each arm of the bridge to reduce the voltage across the individual diodes. Resistors bridge each diode to keep the voltages equal.

The regulator circuit is similar to that discussed in paragraph 3.10 a. and b. Transistors Q1701 through Q1704 and Q1603 and Q1604 all operate in series as the series regulator to keep the

voltage across each transistor within normal limits. A test point TP1301 is located on the top of the circuit board to provide a quick check on regulator output (+450 VDC).

Diode CR1003 and relay K1001 make up a protective circuit to insure prompt opening of the fuse F1010 in the event the regulator is short circuited. Without the protective circuit, the fuse will not open fast enough to prevent damage to the transistors in the regulator. With the protective circuit across the regulator, the current through the diode and relay will rise instantly on short circuit, close the relay contacts and connect the resistor R1027 across the secondary of the power transformer, blowing the fuse.

3.12 -150V and -380V Regulators

a. -150V Regulator. This power supply circuit is supplied from a 148 V AC secondary (terminals 13 and 14) on the power transformer T1002. The rectifier and regulator circuit is identical to the +150 regulator described in paragraph 3.10 a. and b. A test point TP1103 is located on the top of the circuit board to provide a quick check on regulator output (-150 VDC).

b. -380V Regulator. This power supply circuit is supplied from a 358V AC secondary (terminals 5 and 6) on the power transformer T1002. The rectifier and regulator circuits are similar to those described in paragraph 3.10 a. and b. Transistors Q1006 through Q1010 are connected in series to make up the series regulator. This arrangement is used to keep the voltage across the individual transistors to a safe value. A test point TP1202 is located on top of the circuit board to provide a quick check on regulator output (-380 VDC).

A protective diode circuit (CR1005) is connected across the regulator circuit. In the event of a short circuit on the regulator, the voltage drop across the regulator will rise, the diode will begin to conduct heavily and draw sufficient current so that the fuse (F1008) will open instantly. Without the diode circuit, the secondary fuse may not open in time to protect the transistors in the regulator.

3.13 Filament Supply

a. The filament supply transformer (T1001) supplies power to two secondary windings. One of these windings (terminals 8 and 9) supplies the AC heater requirements for the output amplifier tubes.

b. The second winding on the filament transformer is a center tapped 13.8V secondary (terminals 5, 6 and 7) which supplies power to a full wave rectifier. Output of this rectifier is filtered by an LC filter and applied to a series regulator. Transistors Q1601 and Q1602 are connected in parallel in order to handle the total current required from the supply. A .1 ohm resistor in each emitter lead insures an even division of current through the pair. The amount of current passed by the pair of series regulator transistors is controlled by transistor Q1001 which sets the base voltage on the pair.

Since the current drain from this regulated supply is high, the voltage drop in the leads is also quite high. In order for the regulator to compensate for this voltage drop, the regulated heater voltage is sensed at the point of application in the Model 323C regulator unit. Pins 12 and 13 of J1009 carry the sensing voltage from the corresponding pins on J100 in the Model 323C regulator. The sense voltage is applied to transistor Q1304. Transistors Q1304 and Q1305 compare the sensed voltage to a zener diode reference CR1311 and produce an error voltage which, in turn, controls the amplifier (Q1001) and the series regulator.

3.14 Power Supply Interconnection

a. This schematic illustrates the power supply control wiring in the Model 323C. Some of the items shown on the schematic have already been discussed in previous paragraphs. See paragraph 2.1 for power supply connections and paragraph 2.2p. for fuses.

b. Relay K1501 controls the primary power to the Model 323C. It is controlled by the POWER switch on the regulator panel. A thermostat switch (S1601) may also open the relay and shut down the unit. This thermostat is located on the power transistor heat sink and is set to open if the temperature of the heat sink rises above the safe operating level for the transistors.

NOTE

The thermostat may open and shut down the unit if sufficient ventilation is not provided.

c. Relay K1502 controls the time delay function of the unit. The a and b contacts of the relay control the primary supply voltage to the plate voltage power transformer. The relay, in turn, is controlled by the 6 volt thermal time delay relay (K1503). When the unit is switched ON, power is supplied to the filament transformer (T1001). The filaments begin to warm up and the thermal delay relay begins to operate. At the completion of the 30 second delay period, the thermal relay closes. This closes relay K1502 and applies high voltage to the regulators. Relay contacts (section c) hold the relay closed and disconnect the time delay relay.

3.15 Regulator Interconnection

a. This schematic illustrates the wiring which connects the various modules that make up the regulator unit. Most circuits have been discussed in previous paragraphs in this section.

b. The operate relay (K100) is closed by placing the standby switch (S101) in the OPERATE position. The relay then connects the operate light and turns on the chopper drive.

SECTION 4

RECALIBRATION

4.1 Recommended Test Equipment

When recalibrating the Model 323C at periodic recalibration intervals, or after repairs have been made, the following test instruments should be used, or other instruments of similar quality:

Distortion Analyzer	Hewlett Packard Model 330B
Wave Analyzer	Hewlett Packard Model 302A
Audio Oscillator	Holt Model 448
AC Transfer Voltmeter	Holt Model TV1
DC Supply	Kintel Model 304
DC Potentiometer	Leeds & Northrup Model K3
Standard Cell Bank	Eppley Saturated Cells

2. Procedure

a. Power Amplifier Distortion. The output bias controls (R554 and R555) must be adjusted before making distortion measurements. Make this adjustment with the Model 323C in OPERATE at 99.9V at 1 KC internal oscillator. Set the output bias controls (R554 and R555) to give 8.0 VDC across R543 and R544. The distortion may be measured by using either a total harmonic distortion analyzer or a wave analyzer. The latter is preferred because it allows the necessary adjustments without momentarily over-driving the analyzer and allows separate adjustments for the reduction of second and third harmonic components. When measuring distortion, set the output of the Model 323C to 99.9 volts with a 30 watt load. Select a frequency of 1 KC from the internal oscillator. Adjust the balance control (R514) to minimize the second harmonic component. Adjust the output bias controls (R554 and R555) in small equal amounts to minimize the third harmonic component. In no case should the output bias controls be adjusted to give less than 7 VDC or more than 9 VDC as measured across R543 and R544 in the OPERATE condition.

The total distortion should not exceed 0.030% on internal oscillator with no load.

b. Control Amplifier and Meter Calibration. With the Model 323C regulating at a frequency of 1 KC from an external oscillator set the input voltage to one volt. Connect a vacuum tube voltmeter to the grid (Pin 2) of V403B and adjust R448 until the grid voltage measures zero. With the same operating conditions as above, the meter input calibration can be adjusted by depressing the INPUT LEVEL CHECK BUTTON and adjusting R312 until the meter needle reads at the lower edge of the green section of the scale. The output meter can be calibrated by dialing ten volts output (input conditions as above), connecting a 3.3 ohm resistive load to the output terminals and adjusting R306 so the meter reads 30 VA.

c. One Volt Output Calibration. Do not attempt to make this adjustment without precision standards equipment or operation outside of the specifications may result.

With the Model 323C operating at 1 KC and the output voltage set at one volt on the 1 to 1000 volt range, after a one-half hour warmup, measure the output terminal voltage with a precision AC voltmeter. The voltage must be 1.000 ± 0.01%.

To adjust the output voltage, adjust R405 which is accessible through a hole in the rear plate. Clockwise rotation will increase the chopper reference voltage and also the output voltage.

After the correct setting has been obtained, several precision AC to DC transfers should be made to insure the output voltage accuracy. This is important since this adjustment affects all output voltage settings of the Model 323C.

d. Attenuator Ratio Adjustment. Do not attempt to make this adjustment without precision standards equipment or operation outside of specifications may result.

With the Model 323C operating at 1 KC and the output voltage set at two volts, after a one-half hour warmup, measure the output terminal voltage with a precision AC voltmeter. Be sure that all other decades are in the zero position, especially the vernier potentiometer. The voltage must be 2.000 ± 0.01%.

Before this two volt level can be adjusted, it is necessary that the one volt level be previously set as in step c. above. To adjust the two volt level, adjust R704 located on the AC-DC converter assembly. Clockwise rotation will increase the output voltage.

After the correct setting has been obtained, several precision AC to DC transfers should be made to insure the output voltage accuracy. This is important since this adjustment sets the ratio between the attenuator and the converter input and consequently affects all the absolute output voltages above one volt.

e. AC-DC Converter High Frequency Compensation. With the Model 323C operating at 1 KC and the output voltage set at ten volts, obtain a null on the precision AC voltmeter. Change the input frequency in increments up to 20 KC. The output voltage should be within ± 0.015% up to 10 KC and within ± 0.03% up to 20 KC.

To adjust the high frequency compensation, adjust C709 located on the AC-DC converter assembly. Recheck the incremental frequencies to insure the accuracy of this adjustment. This compensation must be accurately adjusted because it will affect the high frequency response of all output voltages by the same percentage. The adjustment of C709 does not affect the absolute output voltage at 1 KC and, therefore, will not affect the absolute adjustment in step c. above.

f. AC-DC Converter Low Frequency Compensation. With the Model 323C operating at 1 KC and the output voltage set at 10 volts, obtain a null on the precision AC voltmeter. Change the input frequency in increments down to 35 cycles. The output voltage should be within ± 0.025% down to 100 cps and within ± 0.04% down to 35 cps.

To adjust the low frequency compensation, adjust R721 located on the AC-DC converter assembly. Recheck the incremental frequencies to insure the accuracy of this adjustment. This compensation must be accurately adjusted because it will affect the low frequency response of all output voltages by the same percentage. The adjustment of R721 does not affect the absolute output voltage at 1 KC and, therefore, will not affect the absolute adjustment in step c. above.

g. With 1 KC internal oscillator frequency selected, adjust C225 for 1 KC within ± 1/2%.

With 50 cps internal oscillator frequency selected, adjust C227 for 50 cps ± 1/2%.

SECTION 5
SERVICING

5.1 Voltage Measurements

As a convenience for maintenance personnel, all of the information required to troubleshoot the Model 323C is supplied on the schematic diagrams. This eliminates the tiresome paging required when voltage charts are used. Waveforms, when required, will also be found on the schematics.

5.2 Conditions for Voltage Measurements

The voltage measurements and the waveforms are all taken with the equipment operating under the following conditions (unless specified otherwise on the schematic diagram).

(1) Input signal level is 1.0 volt RMS at 1 KC at the input terminals. An external oscillator is used.

(2) A 15 voltampere load is applied to the output terminals.

(3) The Output Voltage Selector is set to deliver 45 volts.

(4) Unit is in the OPERATE position.

5.3 DC Voltage Measurements

All DC voltage measurements are printed in blue on the schematics. Readings are taken with a VTVM having an input resistance of 11 megohms. Readings are taken with reference to common. Values shown are ± 20% unless otherwise specified on the schematic.

5.4 AC Measurements and Waveforms

All AC measurements are printed in red on the schematics. Readings are all peak-to-peak values measured with a 10 megohm oscilloscope probe. All readings taken with reference to common. Values shown are ± 10% unless otherwise specificed on the schematic.

5.5 Component Locations

Components are labeled uniformly on schematics, parts lists, and illustrations. Location of a part can be determined by referring to the parts list. The number of the illustration showing the desired part is listed in the right hand column.

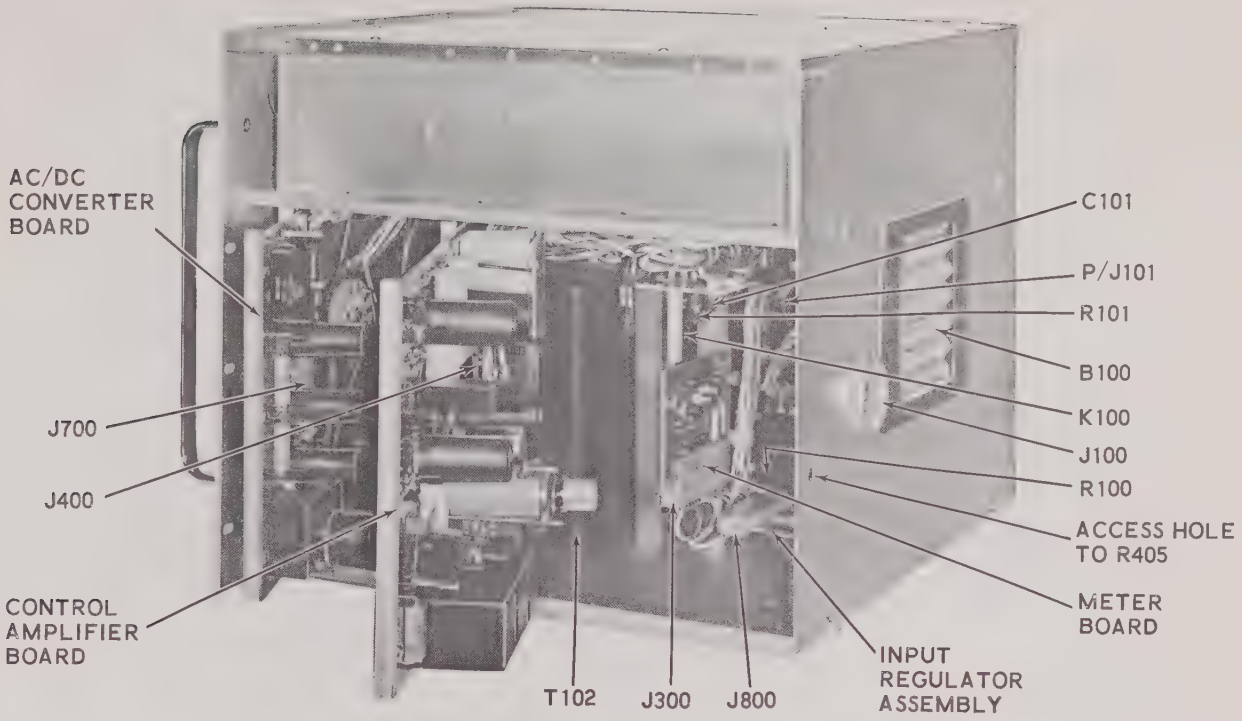


Figure 19. Regulator Assembly - Right Side

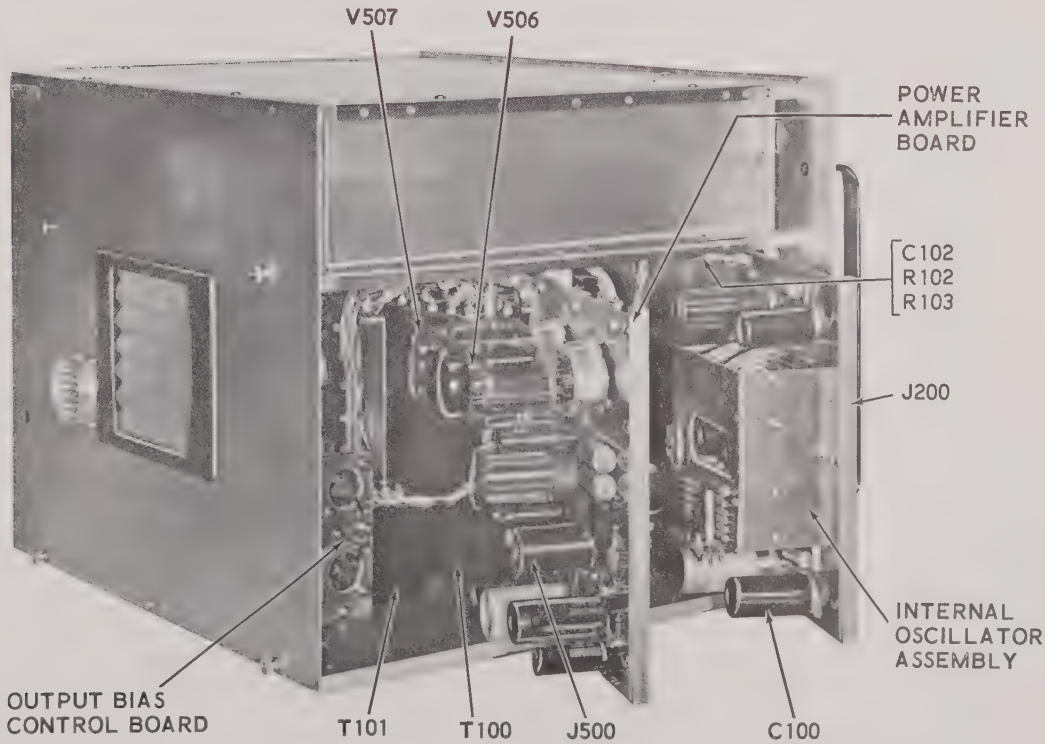


Figure 20. Regulator Assembly - Left Side

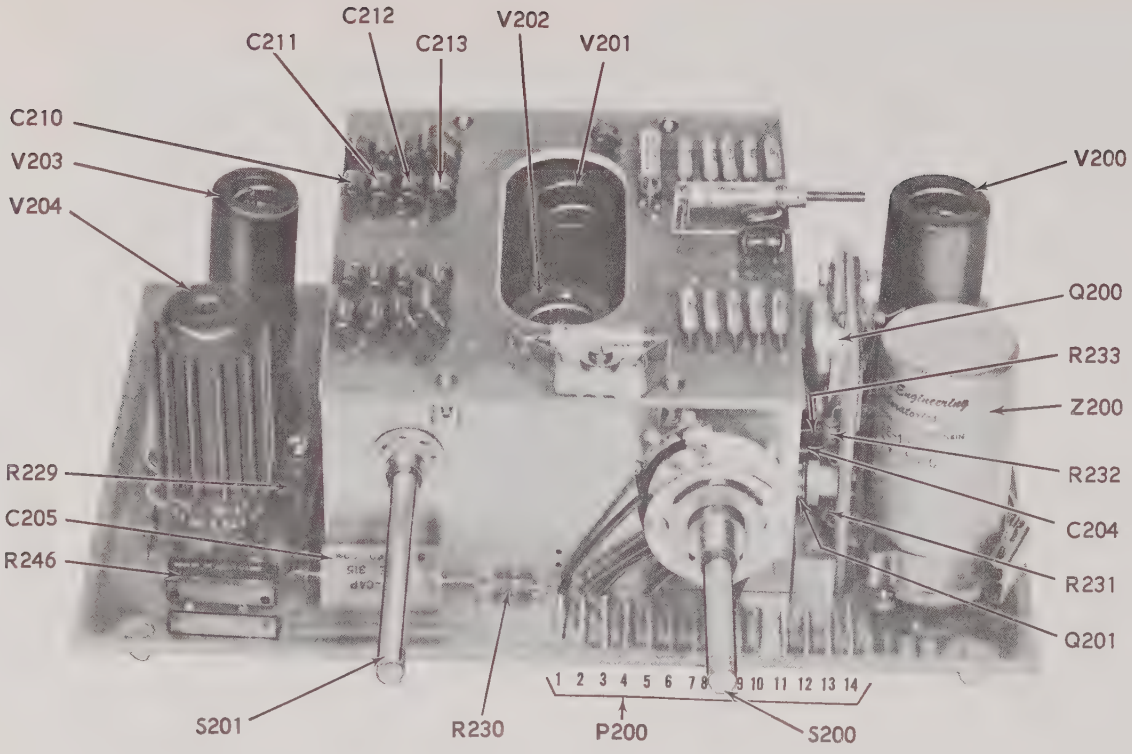


Figure 21. Internal Oscillator Assembly - Front View

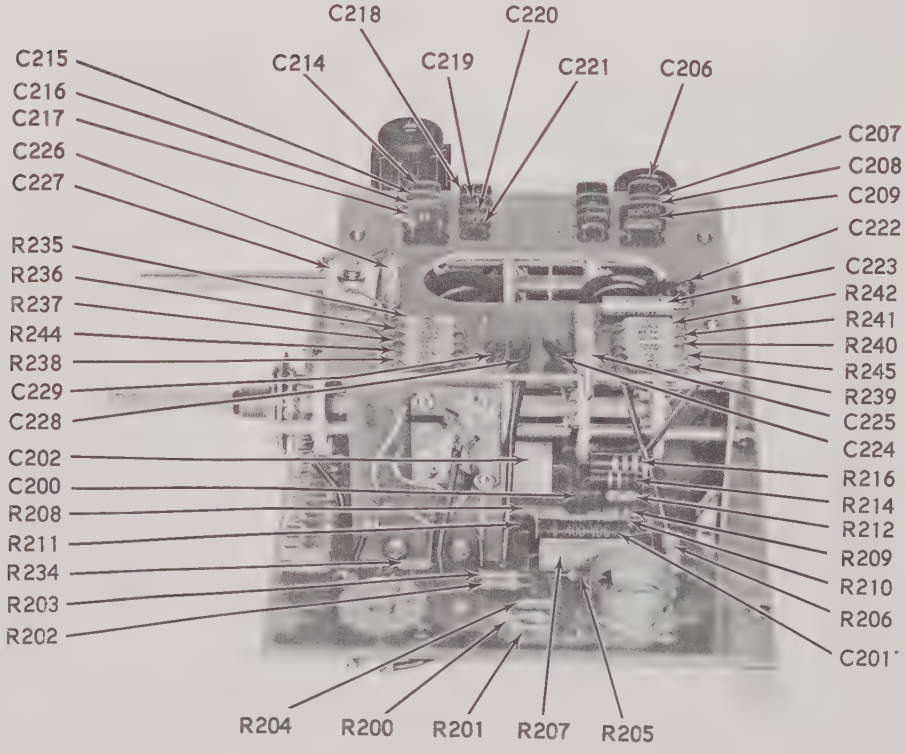


Figure 22. Internal Oscillator Assembly - Right Hand View

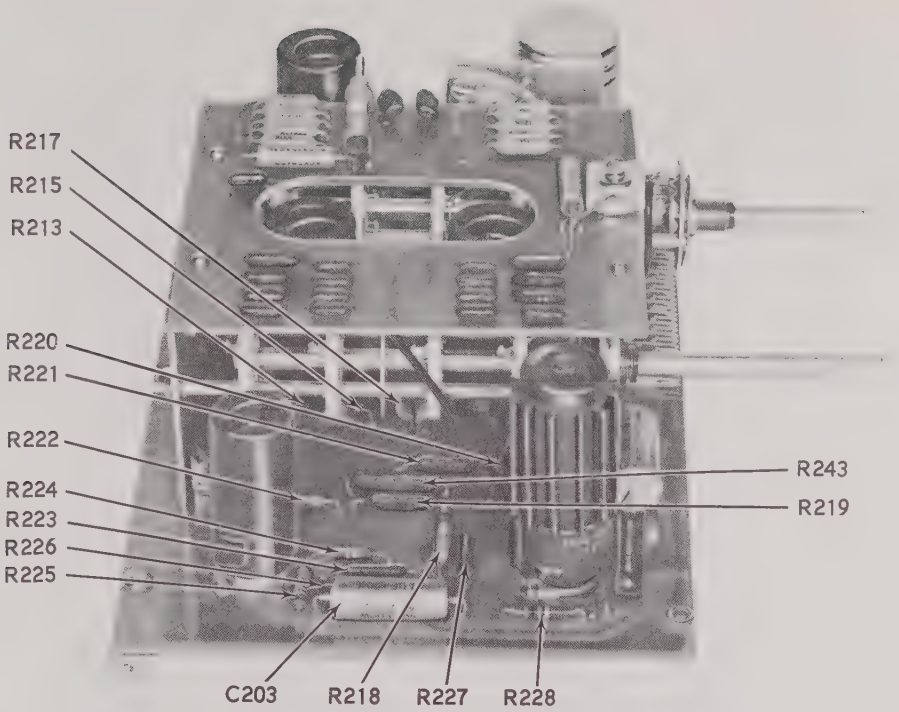


Figure 23. Internal Oscillator Assembly - Left Hand View

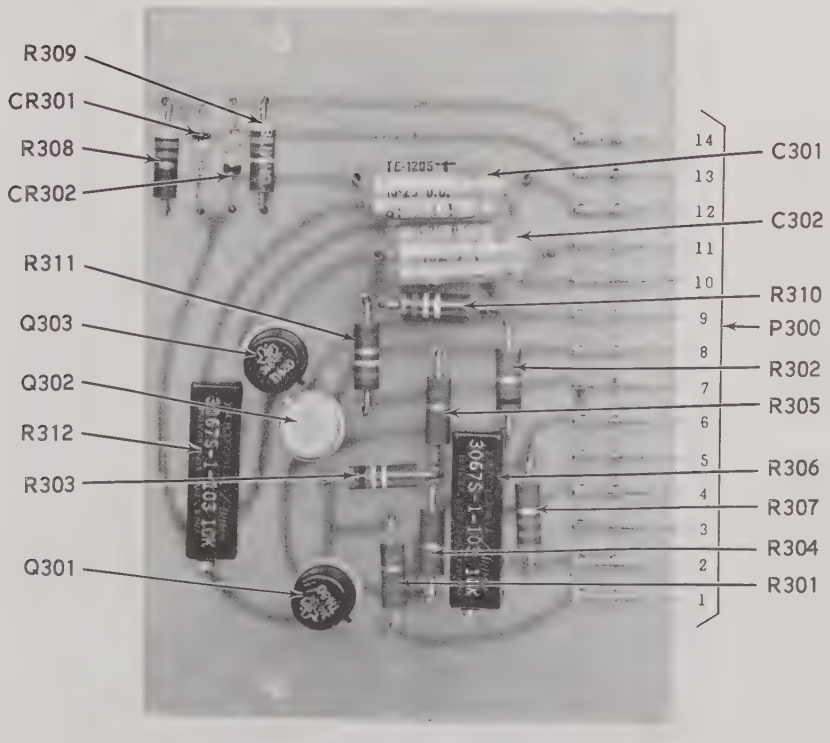


Figure 24. Meter Board

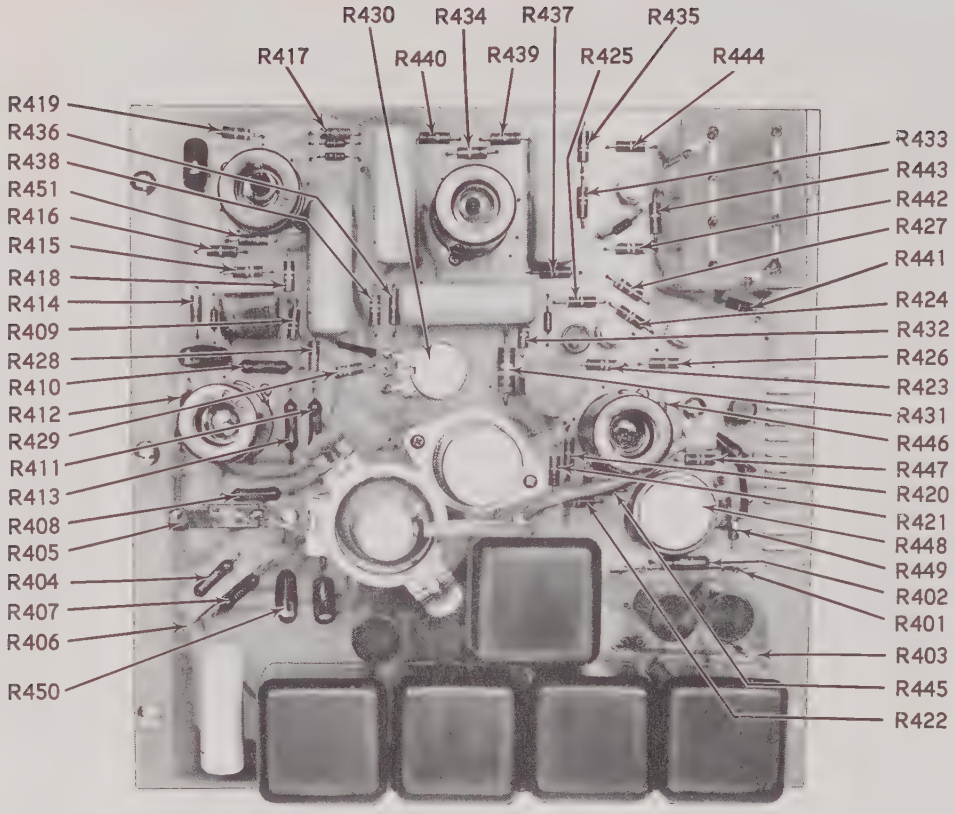


Figure 25. Control Amplifier Board (Resistor Locations)

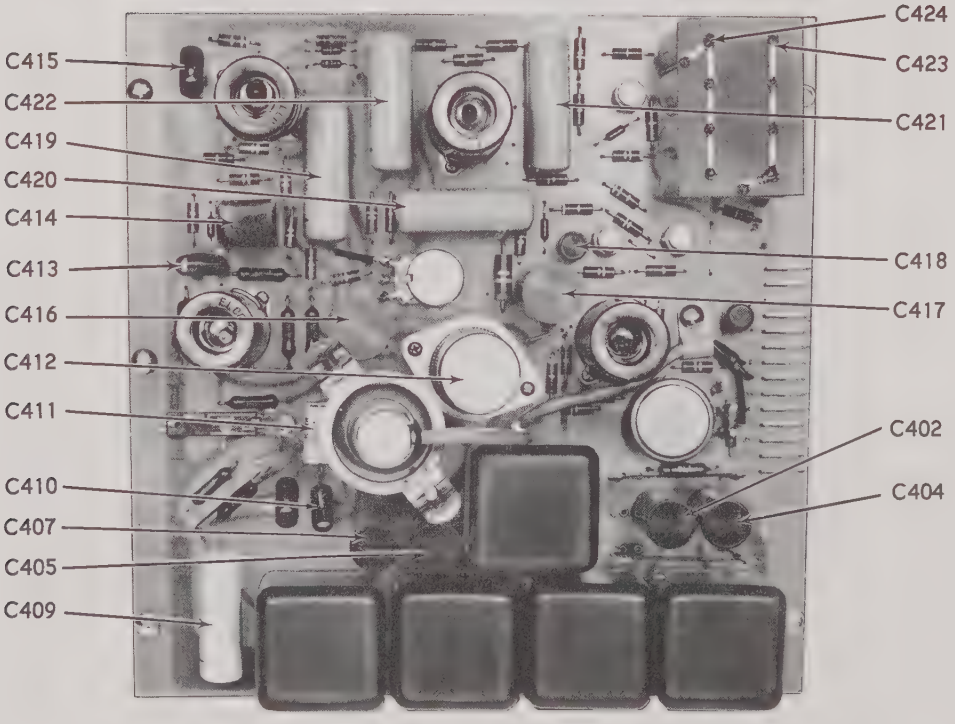


Figure 26. Control Amplifier Board (Capacitor Locations)

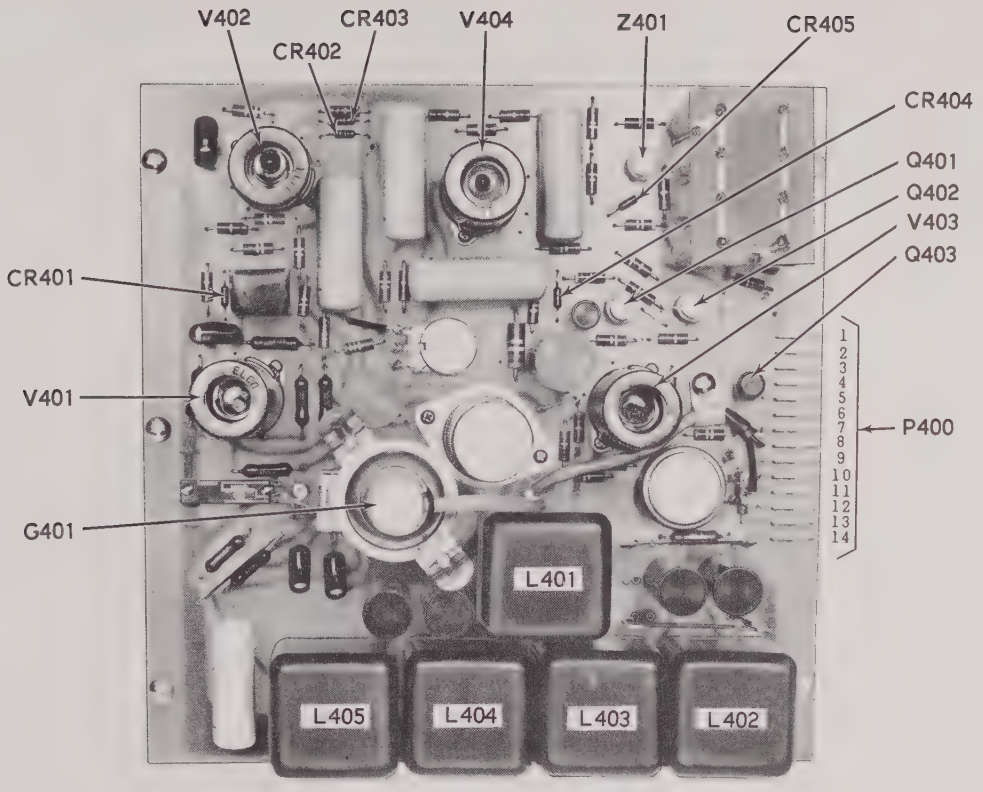


Figure 27. Control Amplifier Board (Miscellaneous Parts Location)

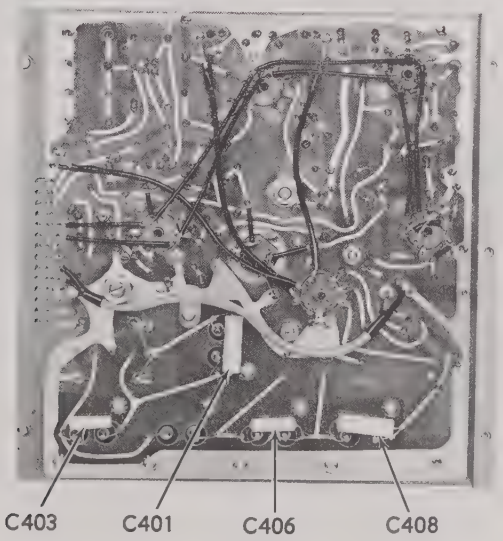


Figure 28. Control Amplifier Board - Back View

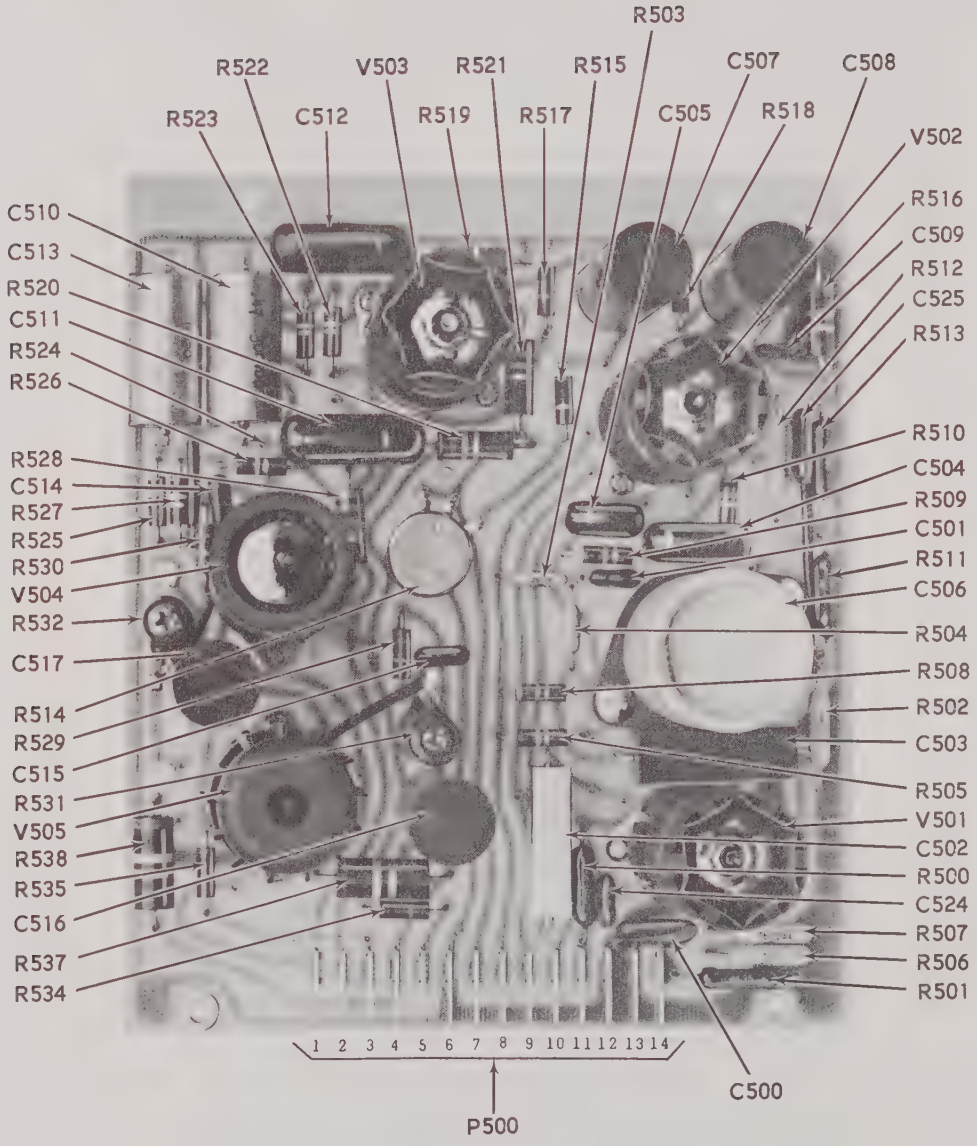


Figure 29. Power Amplifier Board

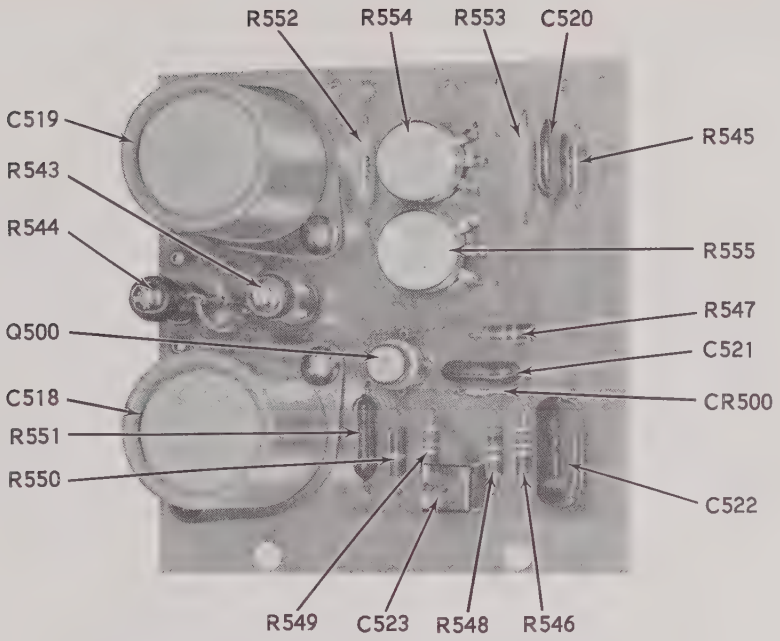


Figure 30. Bias Control Board

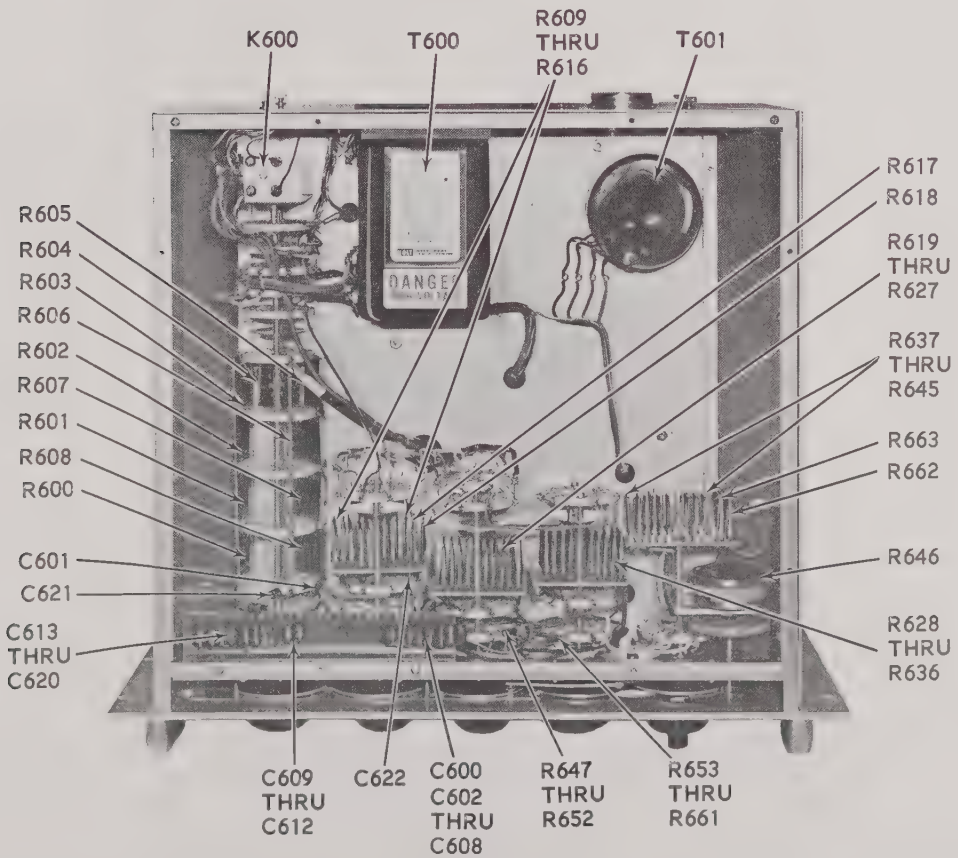


Figure 31. Regulator Assembly - Top View (Attenuator Assembly)

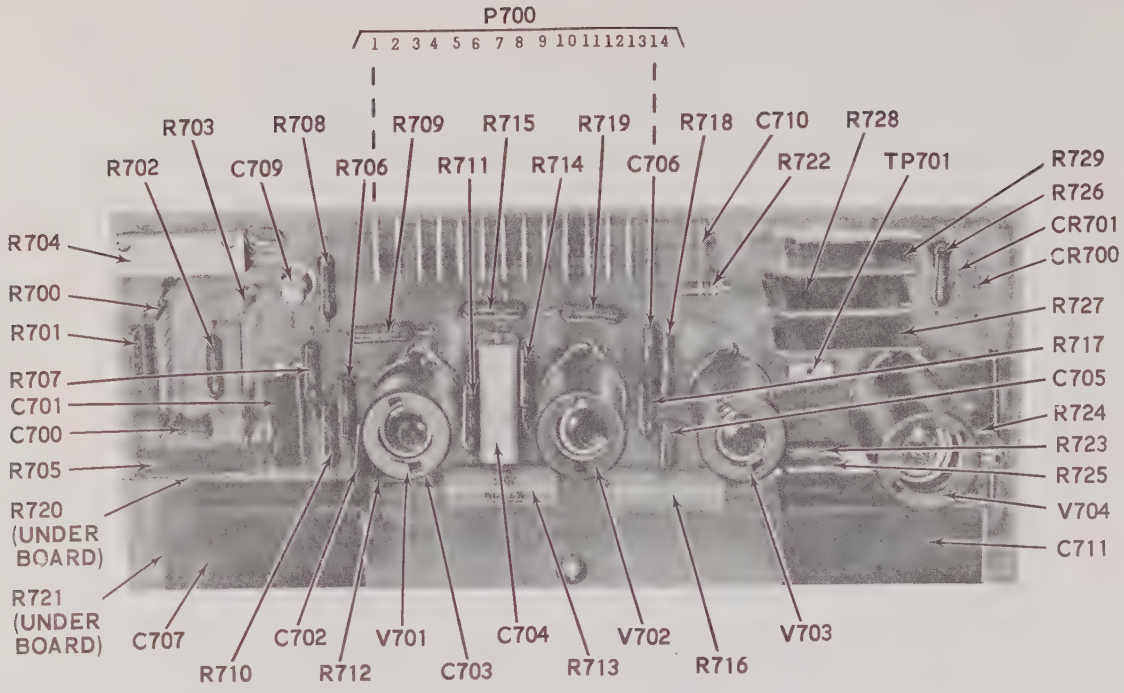


Figure 32. AC to DC Converter Board

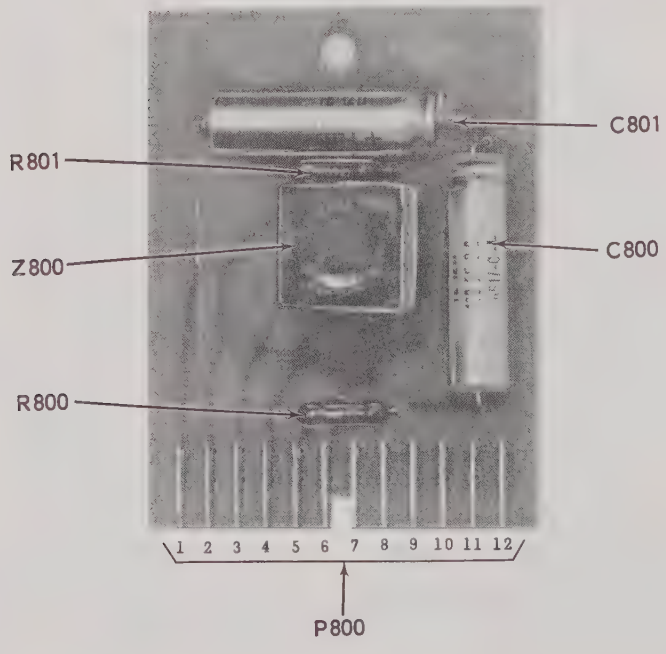


Figure 33. Input Regulator Board

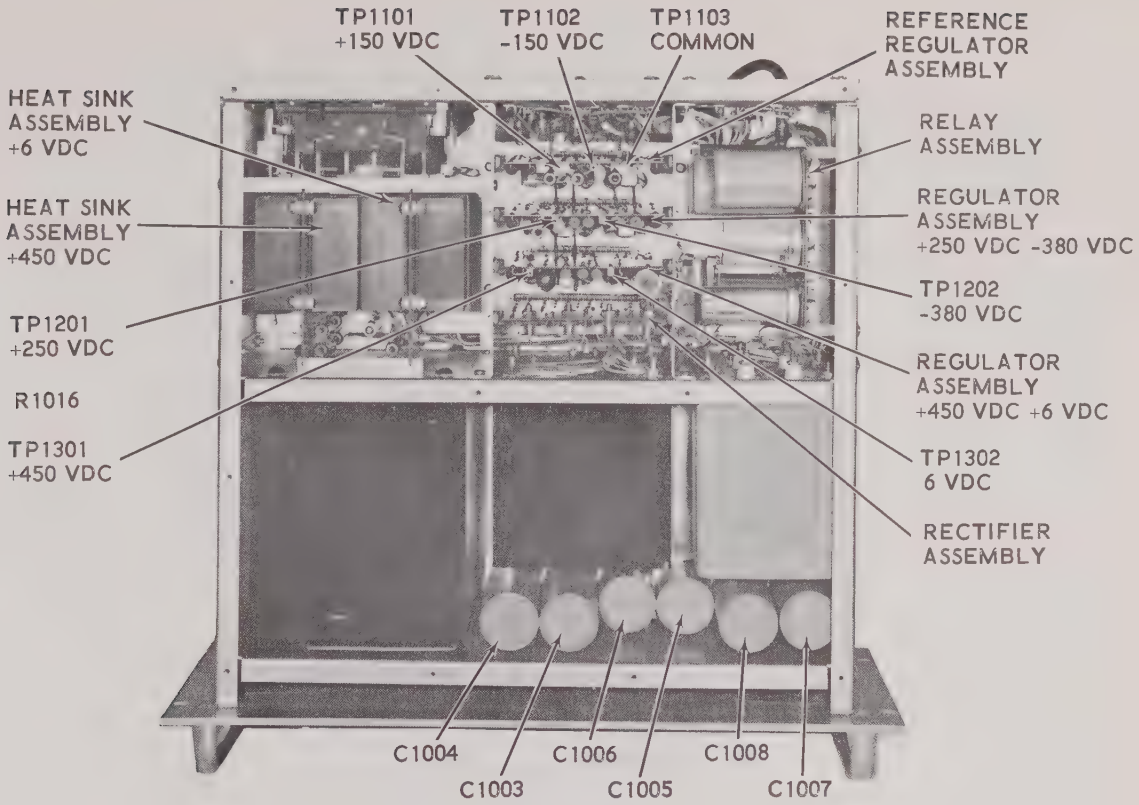


Figure 34. Power Supply - Top View (Regulator Boards in Place)

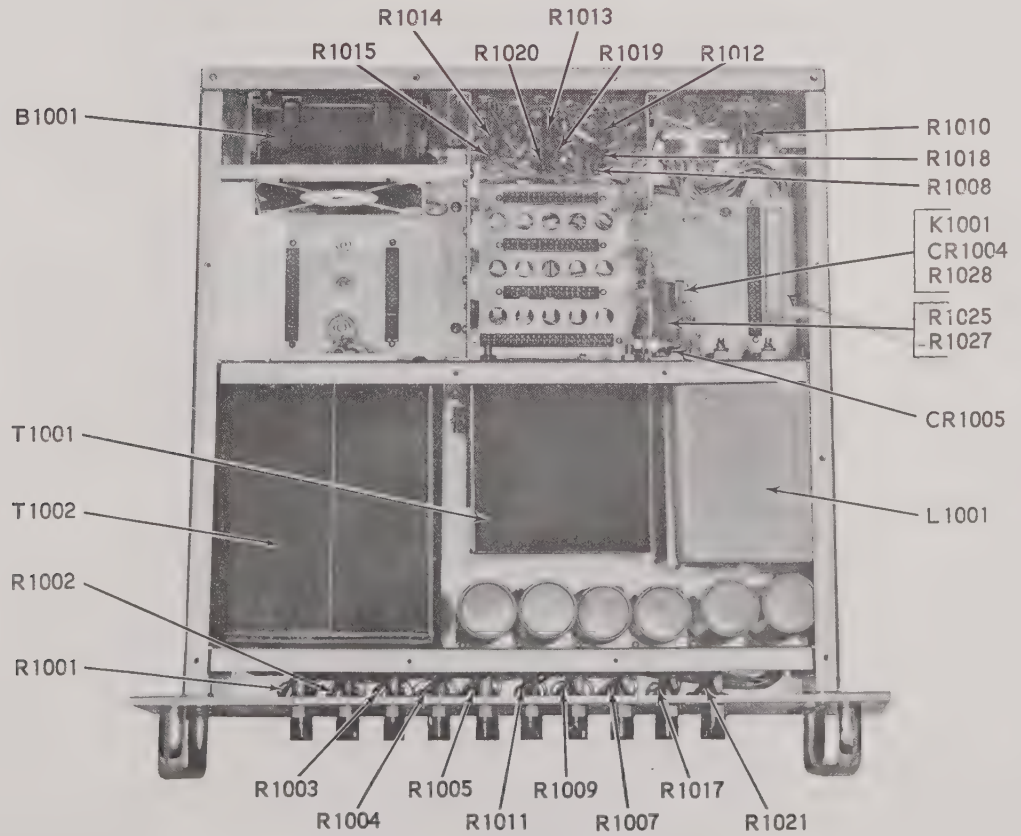


Figure 35. Power Supply - Top View (Regulator Boards Removed)

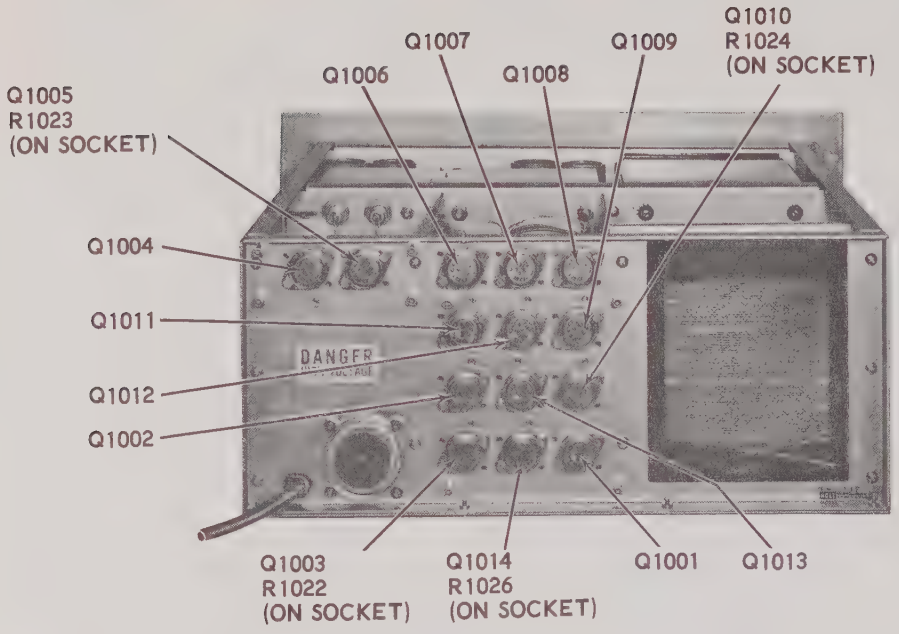


Figure 36. Power Supply - Rear View

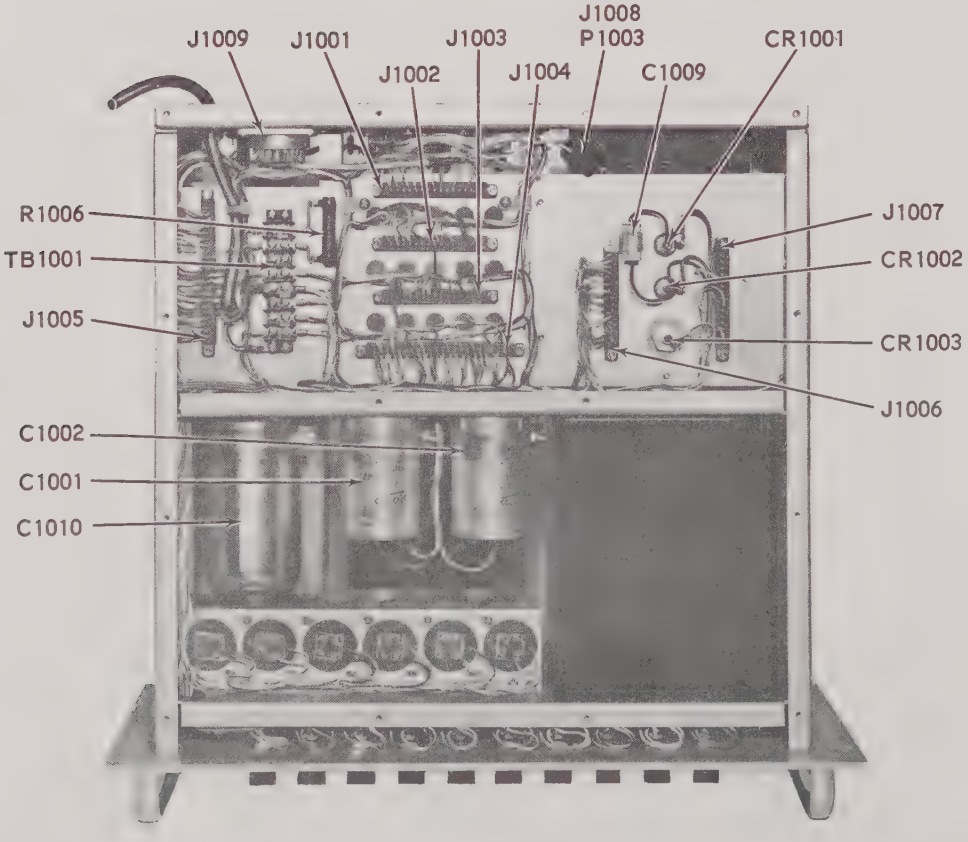


Figure 37. Power Supply - Bottom View

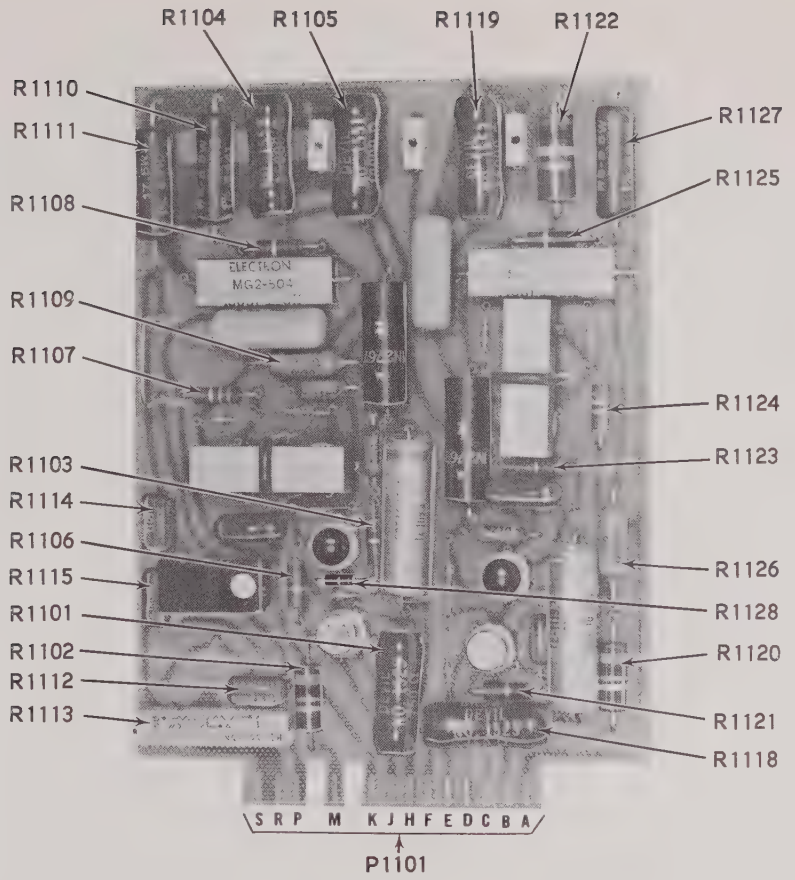


Figure 38A. Regulator Board - +150 VDC, -150 VDC, Reference(Resistor Locations)

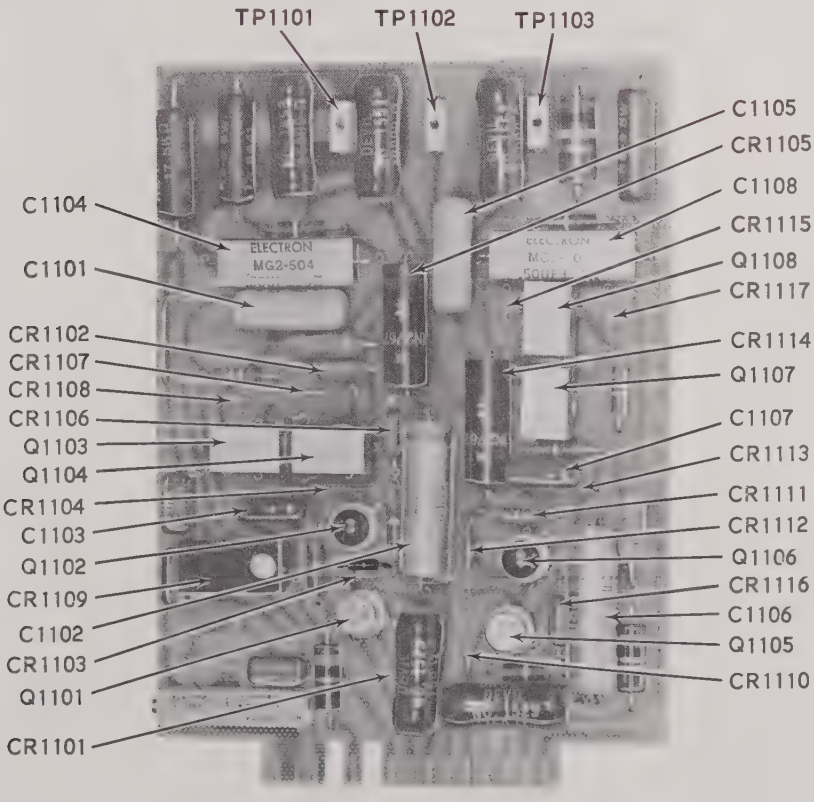


Figure 38B. Regulator Board - +150 VDC, -150 VDC, Reference

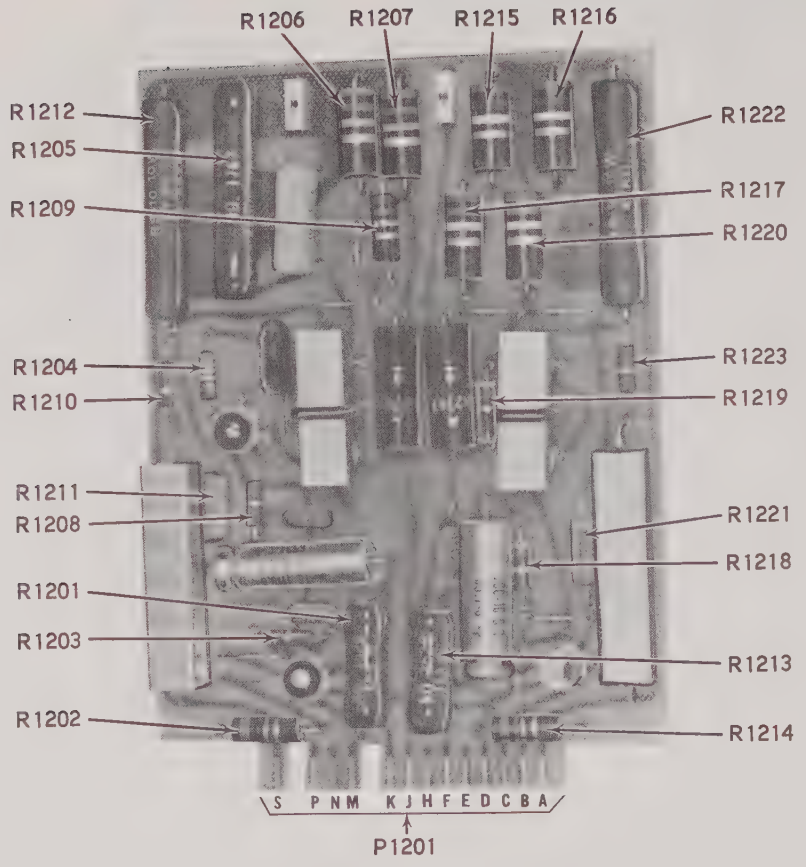


Figure 39A. Regulator Board - +250 VDC, -380 VDC (Resistor Locations)

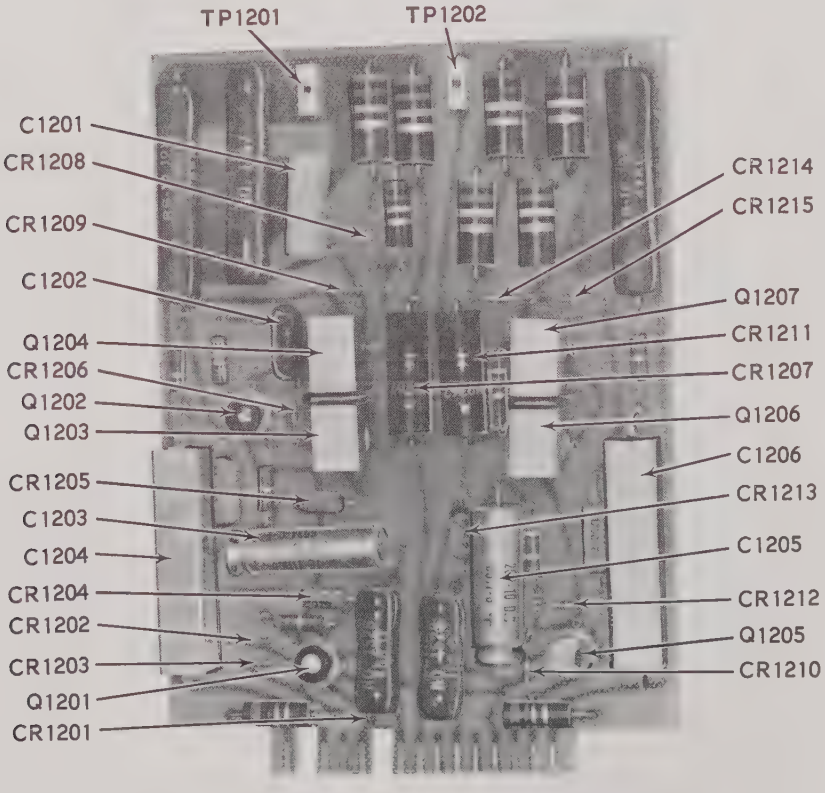


Figure 39B. Regulator Board - +250 VDC, -380 VDC

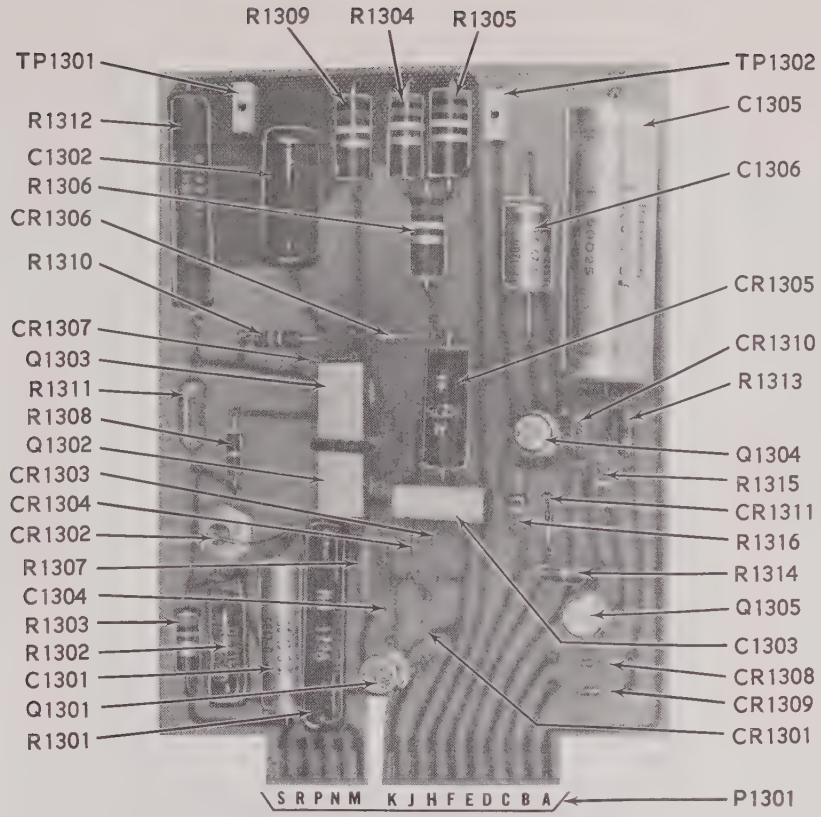


Figure 40. Regulator Board - +450VDC, +6VDC

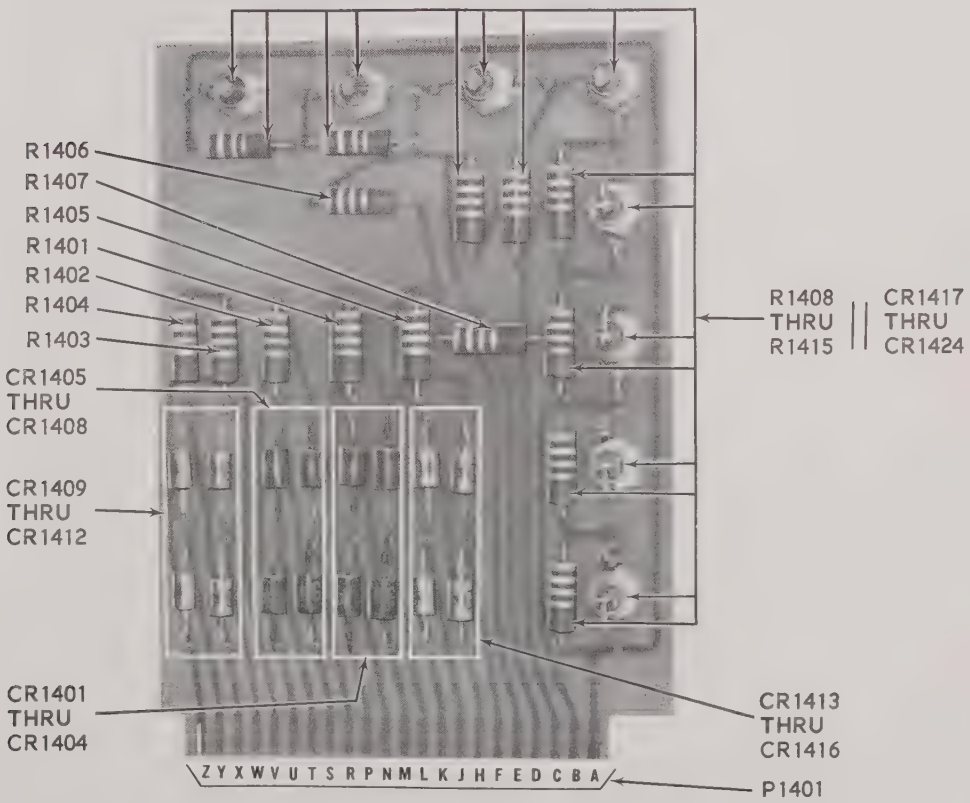


Figure 41. Rectifier Board

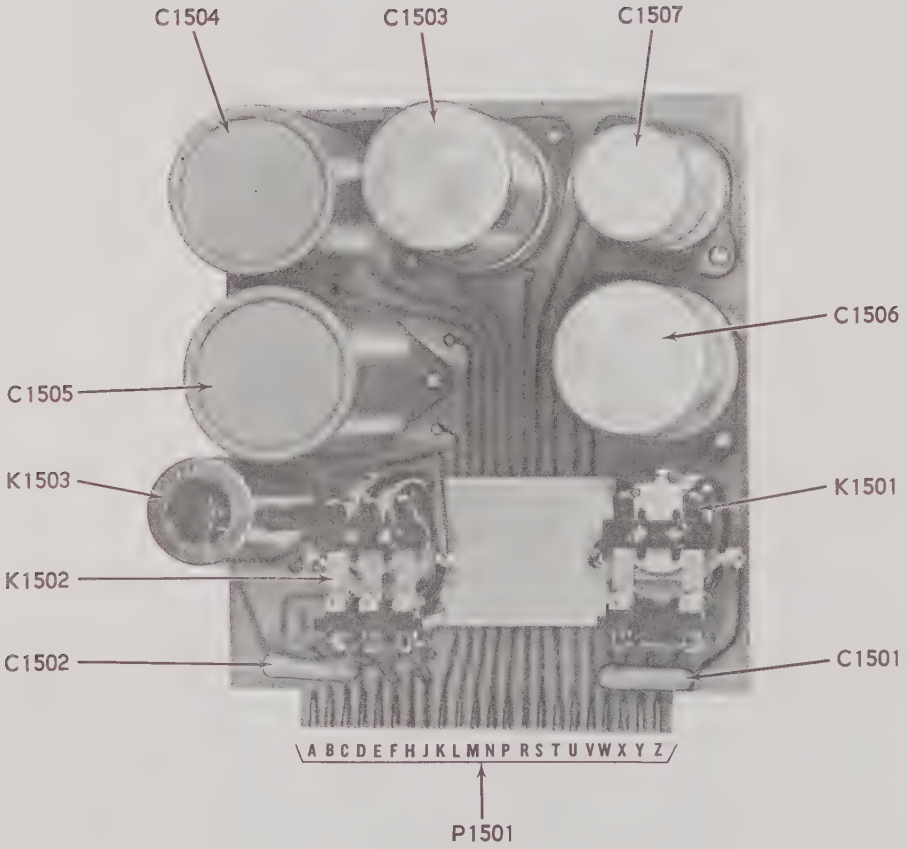


Figure 42. Relay Board

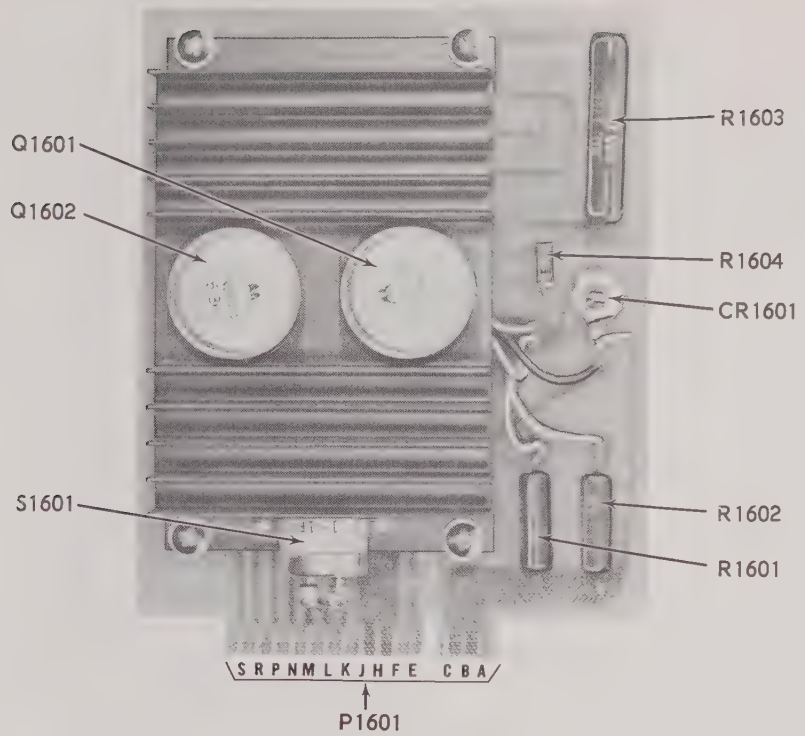


Figure 43. Heat Sink Board - +450VDC, +6VDC (Left Side)

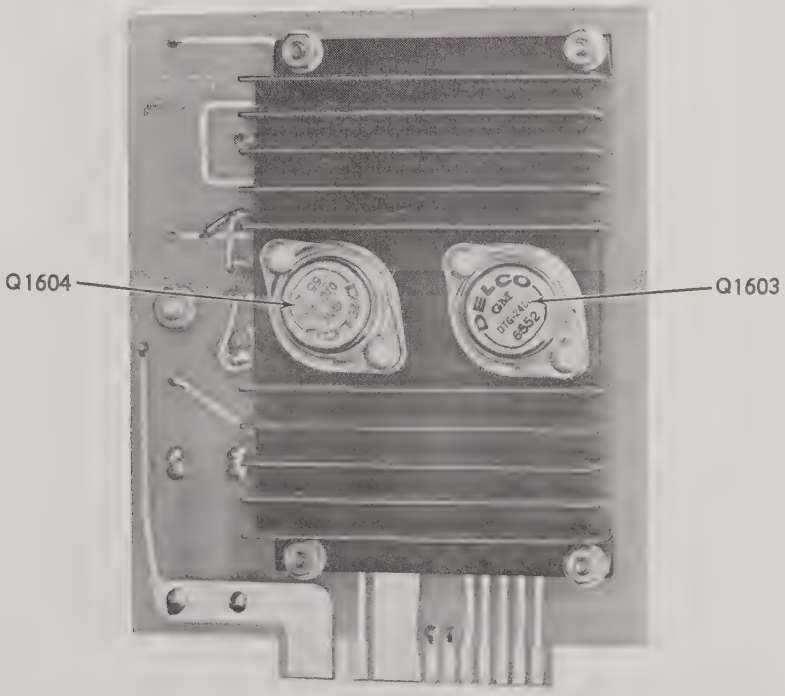


Figure 44. Heat Sink Board - +450VDC, +6VDC (Right Side)

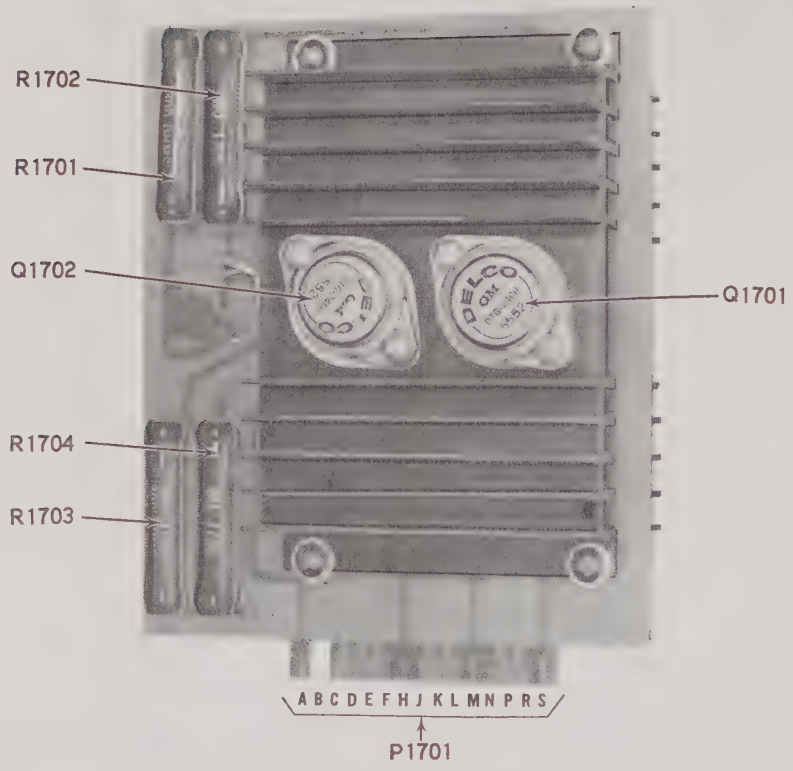


Figure 45. Heat Sink Board - +450VDC (Right Side)

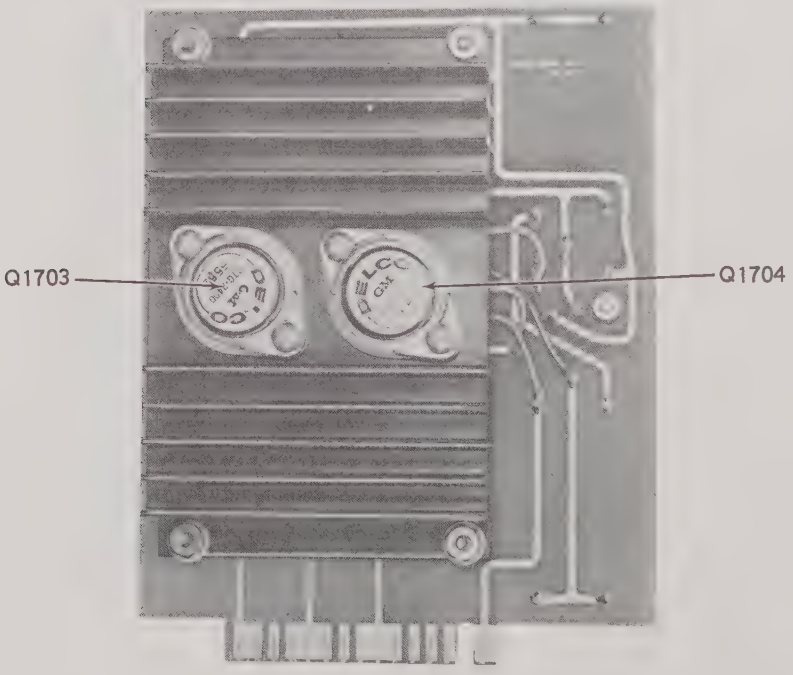


Figure 46. Heat Sink Board - +450VDC (Left Side)

SECTION 6

LIST OF REPLACEABLE PARTS

6.1 Part Numbers

a. General. The part numbers have been chosen to aid the service personnel in locating parts. The parts in the regulator assembly are numbered in the hundreds. The parts in the power supply assembly are labeled in the thousands. The paragraphs that follow list the parts locations on the schematic diagrams.

b. Regulator Assembly. Parts in the regulator assembly are labeled according to the following system:

SCHEMATIC TITLE	SERIES NUMBER
Regulator interconnection	100
Internal oscillator	200
Meter	300
Control amplifier	400
Power amplifier	500
Voltage switching and attenuator	600
AC/DC converter	700
Input regulator	800

c. Power Supply Assembly. Parts in the power supply are labeled according to the following system:

SCHEMATIC TITLE	SERIES NUMBER
Power Supply Main Chassis	1000
Regulator Board - +150VDC, -150VDC, Reference	1100
Regulator Board - +250VDC, -380VDC	1200
Regulator Board - +450VDC, +6VDC	1300
Rectifier Board	1400
Relay Board	1500
Heat Sink Board - +450VDC, +6VDC	1600
Heat Sink Board - +450VDC	1700

6.2 Parts Description

A complete description and the Holt part number is supplied for each replaceable part. When ordering parts, give the complete description, the Holt part number, the reference number, the model number, and the serial number of the equipment. Holt Part Numbers that begin with the number 5XXXX are manufactured or modified by Holt and must be purchased from Holt.

6.3 Parts Illustrations

The location of each part in the illustrations in the manual is simplified by the use of the right hand column on the parts pages titled LOCATION - FIGURE NO. The figure number of the illustration in which this part is shown will appear in this column.

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
B100	Fan, Tube, Axial, 1 Phase, 100 CFM 115 VAC, 60 cps, 14 Watts	8701-004	19
	Filter, Clips and Grill	8703-001	
B1001	Fan, Tube, Axial, 1 Phase, 100 CFM 115 VAC, 60 cps, 14 Watts	8701-004	35
	Filter, Clips and Grill	8703-001	
C100	Capacitor, Fixed, Metallized Paper 1 MFD, 100 V, ± 20%	0902-002	20
C101	Capacitor, Fixed, Mylar .1 MFD, 400 VDC, ± 10%	0903-031	19
C102	Capacitor, Fixed, Electrolytic 20 MFD, 450 VDC, - 10% + 50%	0905-080	20
C200	Capacitor, Fixed, Dur-Mica 51 pf, 500 VDC, ± 10%	0907-042	22
C201	Capacitor, Fixed, Mylar .05 MFD, 400 VDC, ± 10%	0903-025	22
C202	Capacitor, Fixed, Metallized Paper 10 MFD, 100 VDC, ± 20%	0902-030	22
C203	Capacitor, Fixed, Metallized Paper .1 MFD, 400 VDC, ± 20%	0902-023	23
C204	Capacitor, Fixed, Electrolytic 100 MFD, 12 VDC	0905-008	21
C205	Capacitor, Fixed, Metallized Mylar 3 MFD, 50 VDC, ± 20%	0904-008	21
C206	Capacitor, Fixed, Dur-Mica 200 pf, 500 VDC, ± 5%	0907-057	22
C207	Capacitor, Fixed, Dur-Mica 400 pf, 500 VDC, ± 5%	0907-067	22
C208	Capacitor, Fixed, Dur-Mica 600 pf, 300 VDC, ± 5%	0907-006	22
C209	Capacitor, Fixed, Dur-Mica 800 pf, 500 VDC, ± 5%	0907-010	22
C210	Capacitor, Fixed, Dur-Mica 10 pf, 500 VDC, ± 5%	0907-025	21
C211	Capacitor, Fixed, Dur-Mica 20 pf, 500 VDC, ± 5%	0907-029	21
C212	Capacitor, Fixed, Dur-Mica 30 pf, 500 VDC, ± 5%	0907-033	21
C213	Capacitor, Fixed, Dur-Mica 40 pf, 500 VDC, ± 5%	0907-037	21

Circuit Numbers	Description	Holt Part Number	Location Figure No.
C214	Capacitor, Fixed, Dur-Mica 200 pf, 500 VDC, ± 5%	0907-057	22
C215	Capacitor, Fixed, Dur-Mica 400 pf, 500 VDC, ± 5%	0907-067	22
C216	Capacitor, Fixed, Dur-Mica 600 pf, 300 VDC, ± 5%	0907-006	22
C217	Capacitor, Fixed, Dur-Mica 800 pf, 500 VDC, ± 5%	0907-010	22
C218	Capacitor, Fixed, Dur-Mica 10 pf, 500 VDC, ± 5%	0907-025	22
C219	Capacitor, Fixed, Dur-Mica 20 pf, 500 VDC, ± 5%	0907-029	22
C220	Capacitor, Fixed, Dur-Mica 30 pf, 500 VDC, ± 5%	0907-033	22
C221	Capacitor, Fixed, Dur-Mica 40 pf, 500 VDC, ± 5%	0907-037	22
C222*	Capacitor, Fixed, Dur-Mica 160 pf, 500 VDC, ± 20%	0907-053	22
C223	Capacitor, Fixed, Mylar .009 MFD, 100 VDC, ± 1%	0903-016	22
C224	Capacitor, Fixed, Dur-Mica 450 pf, 500 VDC, ± 1%	0907-068	22
C225	Capacitor, Variable 1 - 12 pf	0908-008	22
C226	Capacitor, Fixed, Mylar .009 MFD, 100 VDC, ± 1%	0903-016	22
C227	Capacitor, Variable 9 - 180 pf	0908-006	22
C228	Capacitor, Fixed, Dur-Mica 430 pf, 500 VDC, ± 5%	0907-001	22
C229*	Capacitor, Fixed, Dur-Mica 10 pf, 500 VDC, ± 5%	0907-025	22
C301	Capacitor, Fixed, Electrolytic 15 MFD, 25 VDC	0905-012	24
C302	Capacitor, Fixed, Electrolytic 15 MFD, 25 VDC	0905-012	24
C401	Capacitor, Fixed, Mylar .33 MFD, 100 VDC, ± 1%	0903-080	28
C402	Capacitor, Fixed, Mylar .275 MFD, 50 VDC, ± 1%	0903-001	26

* Factory Selected, Nominal Value Shown

Circuit Numbers	Description	Holt Part Number	Location Figure No.
C403	Capacitor, Fixed, Mylar .043 MFD, 100 VDC, ± 1%	0903-013	28
C404	Capacitor, Fixed, Mylar .35 MFD, 50 VDC, ± 1%	0903-002	26
C405	Capacitor, Fixed, Mylar .35 MFD, 50 VDC, ± 1%	0903-002	26
C406	Capacitor, Fixed, Mylar .043 MFD, 100 VDC, ± 1%	0903-013	28
C407	Capacitor, Fixed, Mylar .275 MFD, 50 VDC, ± 1%	0903-001	26
C408	Capacitor, Fixed, Mylar .22 MFD, 100 VDC, ± 1%	0903-014	28
C409	Capacitor, Fixed, Mylar .5 MFD, 100 VDC, ± 20%	0903-055	26
C410	Capacitor, Fixed, Mylar .006 MFD, 600 VDC, ± 10%	0903-048	26
C411	Capacitor, Fixed, Mylar .5 MFD, 100 VDC, ± 20%	0903-055	26
C412	Capacitor, Fixed, Electrolytic, Dual 20-20 MFD, 350-350 VDC	0905-032	26
C413	Capacitor, Fixed, Mylar .003 MFD, 600 VDC, ± 10%	0903-044	26
C414	Capacitor, Fixed, Metallized Paper 1 MFD, 400 VDC, ± 20%	0902-027	26
C415	Capacitor, Fixed, Mylar .01 MFD, 400 VDC, ± 10%	0903-029	26
C416	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	0901-005	26
C417	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	0901-005	26
C418	Capacitor, Fixed, Electrolytic 5 MFD, 15 VDC	0905-010	26
C419 thru C422	Capacitor, Fixed, Mylar .5 MFD, 400 VDC, ± 10%	0903-079	26
C423 a,b,c,d	Capacitor, Fixed, ~~Metallized Paper~~ Mylar 10 MFD, 100 VDC, ± 20%	0904-026 ~~0902-030~~	26
C424 a,b,c,d	Capacitor, Fixed, ~~Metallized Paper~~ Mylar 10 MFD, 100 VDC, ± 20%	0904-026 ~~0902-030~~	26
C500	Capacitor, Fixed, Dur-Mica 1200 pf, 500 VDC, ± 5%	0907-014	29

Circuit Numbers	Description	Holt Part Number	Location Figure No.
C501	Capacitor, Fixed, Dur-Mica 82 pf, 500 VDC, ± 5%	0907-047	29
C502	Capacitor, Fixed, Metallized Paper .50 MFD, 200 VDC, ± 20%	0902-032	29
C503	Capacitor, Fixed, Metallized Mylar 1.0 MFD, 200 VDC, ± 20%	0904-004	29
C504	Capacitor, Fixed, Mylar .022 MFD, 400 VDC, ± 10%	0903-078	29
C505	Capacitor, Fixed, Mylar .0047 MFD, 600 VDC, ± 10%	0903-047	29
C506	Capacitor, Fixed, Electrolytic 50 MFD, 150 VDC, - 10% + 100%	0905-020	29
C507	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	0901-005	29
C508	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	0901-005	29
C509	Capacitor, Fixed, Dur-Mica 24 pf, 500 VDC, ± 5%	0907-031	29
C510	Capacitor, Fixed, Metallized Mylar .47 MFD, 300 VDC, ± 20%	0904-001	29
C511	Capacitor, Fixed, Mylar .05 MFD, 400 VDC, ± 10%	0903-030	29
C512	Capacitor, Fixed, Mylar .05 MFD, 400 VDC, ± 10%	0903-030	29
C513	Capacitor, Fixed, Metallized Mylar .47 MFD, 300 VDC, ± 20%	0904-001	29
C514	Capacitor, Fixed, Dur-Mica 240 pf, 500 VDC, ± 5%	0907-060	29
C515	Capacitor, Fixed, Dur-Mica 240 pf, 500 VDC, ± 10%	0907-060	29
C516	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	0901-005	29
C517	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	0901-005	29
C518	Capacitor, Fixed, Electrolytic 500 MFD, 25 VDC	0905-017	30
C519	Capacitor, Fixed, Electrolytic 500 MFD, 25 VDC	0905-017	30
C520	Capacitor, Fixed, Dur-Mica 1500 pf, 500 VDC, ± 5%	0907-016	30
C521	Capacitor, Fixed, Dur-Mica 1500 pf, 500 VDC, ± 5%	0907-016	30

Circuit Numbers	Description	Holt Part Number	Location Figure No.
C522	Capacitor, Fixed, Mylar .1 MFD, 100 VDC, ± 10%	0903-010	30
C523	Capacitor, Fixed, Electrolytic 5 MFD, 15 VDC, - 10% + 150%	0905-010	30
C524	Capacitor, Fixed, Dur-Mica 39 pf, 500 VDC, ± 5%	0907-036	29
C525	Capacitor, Fixed, Dur-Mica 800 pf, 500 VDC, ± 5%	0907-010	29
C600*	Capacitor, Fixed, Dur-Mica 680 pf, 300 VDC, ± 5%	0907-079	31
C601*	Capacitor, Fixed, Dur-Mica 10 pf, 500 VDC, ± 5%	0907-025	31
C602*	Capacitor, Fixed, Dur-Mica 800 pf, 500 VDC, ± 5%	0907-010	31
C603*	Capacitor, Fixed, Dur-Mica 910 pf, 500 VDC, ± 5%	0907-012	31
C604*	Capacitor, Fixed, Dur-Mica 1300 pf, 500 VDC, ± 5%	0907-015	31
C605*	Capacitor, Fixed, Dur-Mica 1600 pf, 500 VDC, ± 5%	0907-017	31
C606*	Capacitor, Fixed, Dur-Mica 2400 pf, 500 VDC, ± 5%	0907-020	31
C607*	Capacitor, Fixed, Mylar Paper .0047 MFD, 600 VDC, ± 10%	0903-047	31
C608*	Capacitor, Fixed, Mylar Paper .01 MFD, 100 VDC, ± 10%	0903-004	31
C609*	Capacitor, Fixed, Dur-Mica 2000 pf, 500 VDC, ± 5%	0907-018	31
C610*	Capacitor, Fixed, Dur-Mica 1600 pf, 500 VDC, ± 5%	0907-017	31
C611*	Capacitor, Fixed, Dur-Mica 1300 pf, 500 VDC, ± 5%	0907-015	31
C612*	Capacitor, Fixed, Dur-Mica 800 pf, 500 VDC, ± 5%	0907-010	31
C613*	Capacitor, Fixed, Dur-Mica 1600 pf, 500 VDC, ± 5%	0907-017	31
C614*	Capacitor, Fixed, Dur-Mica 1500 pf, 500 VDC, ± 5%	0907-016	31
C615*	Capacitor, Fixed, Dur-Mica 1300 pf, 500 VDC, ± 5%	0907-015	31

* Factory Selected, Nominal Value Shown

Circuit Number	Description	Holt Part Number	Location Figure No.
C616*	Capacitor, Fixed, Dur-Mica 1200 pf, 500 VDC, ± 5%	0907-014	31
C617*	Capacitor, Fixed, Dur-Mica 910 pf, 500 VDC, ± 5%	0907-012	31
C618*	Capacitor, Fixed, Dur-Mica 500 pf, 500 VDC, ± 5%	0907-003	31
C619*	Capacitor, Fixed, Dur-Mica 27 pf, 500 VDC, ± 5%	0907-032	31
C620* & C621*	Capacitor, Fixed, Dur-Mica 10 pf, 500 VDC, ± 5%	0902-025	31
C622*	Capacitor, Fixed, Dur-Mica 75 pf, 500 VDC, ± 5%	0907-046	31
C700*	Capacitor, Fixed, Dur-Mica 68 pf, 500 VDC, ± 5%	0907-045	32
C701	Capacitor, Fixed, Metallized Mylar .25 MFD, 200 VDC, ± 20%	0904-006	32
C702	Capacitor, Fixed, Dur-Mica 1500 pf, 500 VDC, ± 5%	0907-016	32
C703	Capacitor, Fixed, Dur-Mica 100 pf, 500 VDC, ± 5%	0907-049	32
C704	Capacitor, Fixed, Metallized Paper .50 MFD, 200 VDC, ± 20%	0902-032	32
C705	Capacitor, Fixed, Dur-Mica 470 pf, 500 VDC, ± 5%	0907-002	32
C706	Capacitor, Fixed, Dur-Mica 12 pf, 500 VDC, ± 5%	0907-026	32
C707	Capacitor, Fixed, Metallized Mylar 4.5 MFD, 200 VDC, ± 5%	0904-005	32
C709	Capacitor, Variable, Glass Tube .7 - 9 pf, 750 VDC	0908-009	32
C710	Capacitor, Fixed, Ceramic Disc .01 MFD, 600 VDC, GMV	0906-001	32
C711	Capacitor, Fixed, Metallized Mylar 5 MFD, 200 VDC, ± 5%	0904-003	32
C800 & C801	Capacitor, Fixed, Electrolytic 100 MFD, 25 VDC, - 10% + 75%	0905-046	33
C1001 & C1002	Capacitor, Fixed, Electrolytic 750 MFD, 250 VDC	0905-065	37
C1003 & C1004	Capacitor, Fixed, Electrolytic 320 MFD, 350 VDC	0905-066	34

* Factory Selected, Nominal Value Shown

Circuit Number	Description	Holt Part Number	Location Figure No.
C1005 & C1006	Capacitor, Fixed, Electrolytic 80 MFD, 350 VDC	0905-027	34
C1007 & C1008	Capacitor, Fixed, Electrolytic 320 MFD, 350 VDC	0905-066	34
C1009	Capacitor, Fixed, Metallized Paper 2 MFD, 100 VDC, ± 20%	0902-004	37
C1010	Capacitor, Fixed, Electrolytic 19000 MFD, 25 VDC	0905-015	37
C1101	Capacitor, Fixed, Mylar .05 MFD, 400 VDC, ± 10%	0903-030	38B
C1102	Capacitor, Fixed, Electrolytic 200 MFD, 10 VDC, - 10% + 75%	0905-006	38B
C1103	Capacitor, Fixed, Mylar .0033 MFD, 600 VDC, ± 10%	0903-045	38B
C1104	Capacitor, Fixed, Metallized Paper 0.5 MFD, 200 VDC, ± 20%	0902-032	38B
C1105	Capacitor, Fixed, Mylar .05 MFD, 400 VDC, ± 10%	0903-030	38B
C1106	Capacitor, Fixed, Electrolytic 200 MFD, 10 VDC, - 10% +75%	0905-006	38B
C1107	Capacitor, Fixed, Mylar .01 MFD, 100 VDC, ± 10%	0903-004	38B
C1108	Capacitor, Fixed, Metallized Paper 0.5 MFD, 200 VDC, ± 20%	0902-032	38B
C1201	Capacitor, Fixed, Mylar .05 MFD, 400 VDC, ± 10%	0903-034	39B
C1202	Capacitor, Fixed, Mylar .0033 MFD, 600 VDC, ± 10%	0903-045	39B
C1203	Capacitor, Fixed, Electrolytic 200 MFD, 10 VDC, - 10% + 75%	0905-006	39B
C1204	Capacitor, Fixed, Metallized Paper 0.5 MFD, 400 VDC, ± 20%	0902-049	39B
C1205	Capacitor, Fixed, Electrolytic 200 MFD, 10 VDC, - 10% +75%	0905-006	39B
C1206	Capacitor, Fixed, Metallized Paper 0.5 MFD, 400 VDC, ± 20%	0902-049	39B
C1301	Capacitor, Fixed, Electrolytic 200 MFD, 10 VDC, - 10% +75%	0905-006	40
C1302	Capacitor, Fixed, Mylar 0.1 MFD, 600 VDC, ± 10%	0903-053	40
C1303	Capacitor, Fixed, Mylar 0.47 MFD, 50 VDC, ± 10%	0903-073	40

Circuit Number	Description	Holt Part Number	Location Figure No.
C1304	Capacitor, Fixed, Mylar .047 MFD, 100 VDC, ± 10%	0903-008	40
C1305	Capacitor, Fixed, Electrolytic 500 MFD, 25 VDC	0905-014	40
C1306	Capacitor, Fixed, Electrolytic 20 MFD, 25 VDC, - 10% + 75%	0905-047	40
C1501 & C1502	Capacitor, Fixed, Mylar .05 MFD, 400 VDC, ± 10%	0903-034	42
C1503 & C1504	Capacitor, Fixed, Electrolytic 80 MFD, 350 VDC	0905-027	42
C1505	Capacitor, Fixed, Electrolytic 80 MFD, 450 VDC, - 10% + 50%	0905-076	42
C1506	Capacitor, Fixed, Electrolytic 80 MFD, 350 VDC	0905-027	42
C1507	Capacitor, Fixed, Electrolytic 40 MFD, 500 VDC, - 10% + 50%	0905-075	42
CR301	Diode, Germanium, 85 PIV, 1N48	0302-001	24
CR302	Diode, Germanium, 85 PIV, 1N48	0302-001	24
CR303	Diode, Silicon, 36 PIV, 100 MA, 1N482	0301-017	
CR401 thru CR405	Diode, Silicon, Quick Recovery 125 PIV, 4 MA, 1N628	0301-003	27
CR500	Diode, Silicon, Quick Recovery 125 PIV, 4 MA, 1N628	0301-003	30
CR700	Diode, Silicon, 75 PIV, 75 MA, 1N916A	0301-013	32
CR701	Diode, Silicon, 75 PIV, 75 MA, 1N916A	0301-013	32
CR1001 & CR1002	Diode, Silicon, 50 PIV, 15 A, 1N368A	0301-024	37
CR1003	Diode, Zener, 200 V, 50 Watts ± 20%, 1N3350	0303-015	37
CR1004	Diode, Silicon, 600 PIV, 750 MA 1N3641	0301-021	35
CR1005	Diode, Zener, 200 V, 50 Watts ± 20% 1N3350	0303-015	35
CR1101	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	38B
CR1102	Diode, Zener, 10 V, ± 20%, SZ10	0303-020	38B
CR1103	Diode, Silicon, 6 PIV, Stabister 0.64 V, ± 10% @ 1 MA, 1N816	0301-026	38B
CR1104	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	38B

Circuit Number	Description	Holt Part Number	Location Figure No.
CR1105	Diode, Zener, 20.4 V, ± 5%, .005%/°C, 1N2767	0303-018	38B
CR1106	Diode, Zener, 6.2 V, ± 20%, SZ6.2	0303-017	38B
CR1107 & CR1108	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	38B
CR1109	Reference Diode Assembly	83548	3-38B
CR1110	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	38B
CR1111	Diode, Zener, 10 V, ± 20%, SZ10	0303-020	38B
CR1112	Diode, Silicon, 6 PIV, Stabister, 0.64 V, ± 10% @ 1 MA, 1N816	0301-026	38B
CR1113	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	38B
CR1114	Diode, Zener, 20.4 V, ± 5% .005%/°C, 1N2767	0303-018	38B
CR1115	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	38B
CR1116	Diode, Zener, 6.2 V, ± 20%, SZ6.2	0303-017	38B
CR1117	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	38B
CR1201	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	39B
CR1202 & CR1203	Diode, Silicon, 6 PIV, Stabister, 0.64 V, ± 10% @ 1 MA, 1N816	0301-026	39B
CR1204	Diode, Zener, 6.2 V, ± 20%, SZ6.2	0303-017	39B
CR1205	Diode, Zener, 10 V, ± 20%, SZ10	0303-020	39B
CR1206	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	39B
CR1207	Diode, Zener, 20.4 V, ± 5%, .005%/°C, 1N2767	0303-018	39B
CR1208 thru CR1210	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	39B
CR1211	Diode, Zener, 20.4 V, ± 5%, .005%/°C, 1N2767	0303-018	39B
CR1212	Diode, Silicon, 6 PIV, Stabister, 0.64 V, ± 10% @ 1 MA, 1N816	0301-026	39B
CR1213	Diode, Zener, 6.2 V, ± 20%, SZ10	0303-017	39B
CR1214 & CR1215	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	39B
CR1301	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	40
CR1302	Diode, Zener, 5.6 V, ± 5%, 3.5 Watts, 1N1590	0303-019	40
CR1303 & CR1304	Diode, Silicon, 6 PIV, Stabister, 0.64 V, ± 10% @ 1 MA, 1N816	0301-026	40
CR1305	Diode, Zener, 20.4 V, ± 5%, .005%/°C, 1N2767	0303-018	40

Circuit Number	Description	Holt Part Number	Location Figure No.
CR1306 thru CR1309	Diode, Silicon, 125 PIV, 25 MA, 1N628	0301-003	40
CR1310	Diode, Zener, 6.2 V, ± 20%, SZ6.2	0303-017	40
CR1311	Diode, Zener, 6.1 V, ± 1% @ 20 MA, .4M6.1AZ1	0303-016	40
CR1401 thru CR1408	Diode, Silicon, 400 PIV, 750 MA, 1N3640	0301-020	41
CR1409 thru CR1412	Diode, Silicon, 800 PIV, 500 MA, 1N3642	0301-022	41
CR1413 thru CR1416	Diode, Silicon, 600 PIV, 750 MA, 1N3641	0301-021	41
CR1417 thru CR1424	Diode, Silicon, 500 PIV, 5 Amps, 366K	0301-023	41
CR1601	Diode, Silicon, 50 PIV, 15 Amps, 1N368A	0301-024	43
DS100 DS102 & DS103	Lamp, Incandescent, Cartridge, T-1-3/4 .04 Amp., 6 Volts, White	0502-006	3
DS104 & DS105	Lamp, Incandescent, Cartridge, T-1-3/4 .2 Amp, 6 Volts, Red	0502-007	3
DS1001 thru DS1010	Lamp Assembly, Neon, Red Lens, 115 V	0502-008	4
F1001	Fuse, Slo-Blo, 8 Amp, 250 V	1002-011	4
F1002 & F1003	Fuse, Slo-Blo, 1 Amp, 250 V	1002-004	4
F1004 & F1005	Fuse, Slo-Blo, 3 Amp, 250 V	1002-008	4
F1006 & F1007	Fuse, Slo-Blo, .175 Amp, 250 V	1002-019	4
F1008	Fuse, Slo-Blo, .100 Amp, 250 V	1002-017	4
F1009	Fuse, Slo-Blo, .175 Amp, 250 V	1002-019	4
F1010	Fuse, Slo-Blo, .700 Amp, 250 V	1002-018	4
G401	Chopper	1204-006	27
J100	Connector, Receptacle, 32 Contacts	1701-017	19
J101	Connector, Receptacle, 2 Contacts, 15 Amps	1701-065	19
J102	Terminal, Binding Post, Brass, Nylon Plastic Insulation, Black	1803-017	3

Circuit Numbers	Description	Holt Part Number	Location Figure No.
J103 thru J105	Terminal, Binding Post, Brass, Nylon Plastic Insulation, Red	1803-018	3
J106 & J107	Terminal, Binding Post, Brass, Nylon Plastic Insulation, Black	1803-017	3
J200	Connector, Receptacle, Precious Metal Contacts, 10 Amps, 14 Contacts	1701-016	20
J300	Connector, Receptacle, Precious Metal Contacts, 10 Amps, 14 Contacts	1701-016	19
J400	Connector, Receptacle, Precious Metal Contacts, 10 Amps, 14 Contacts	1701-016	19
J500	Connector, Receptacle, Precious Metal Contacts, 10 Amps, 14 Contacts	1701-016	20
J700	Connector, Receptacle, Precious Metal Contacts, 10 Amps, 14 Contacts	1701-016	19
J800	Connector, Receptacle, 10 Amps, 12 Contacts	1701-015	19
J1001 & J1002	Connector, Receptacle, 15 Pin, Female	1701-064	37
J1003	Connector, Receptacle, 15 Pin, Female	1701-059	37
J1004 & J1005	Connector, Receptacle, 22 Pin, Female	1701-055	37
J1006 & J1007	Connector, Receptacle, 15 Pin, Female	1701-064	37
J1008	Connector, Receptacle, 2 Pin, Female	1701-065	37
J1009	Connector, Receptacle, 32 Pin, Female	1701-019	37
K100	Relay, Switching, 4PDT, 36 Ohms, 6 VDC	1203-004	19
K600	Relay, Switching, 4 PDT, 36 Ohms, 6 VDC	1203-004	31
K1001	Relay, DPST, 50 MA DC, 50 M Sec. Delay, H.V. Contacts	1203-018	35
K1501	Relay, 115 VAC, DPDT	1203-005	42
K1502	Relay, 6 VDC, 3PDT	1203-008	42
K1503	Time Delay Relay, 6 V, 30 Sec. SPST	1201-003	42
L401	Choke, Audio, Iron Core, 132 h, ± 1%	1501-007	27
L402	Choke, Audio, Iron Core, 350 h, 2430 Ohms DC, ± 10%	1501-005	27
L403	Choke, Audio, Iron Core, 435 h, 2375 Ohms DC, ± 10%	1501-004	27
L404	Choke, Audio, Iron Core, 350 h, 2430 Ohms DC, ± 10%	1501-005	27
L405	Choke, Audio, Iron Core, 127 h, 720 Ohms DC, ± 10%	1501-003	27
L1001	Choke, Swinging, Dual Winding	1501-001	35

Circuit Number	Description	Holt Part Number	Location Figure No.
M100	Meter, DC, 0-2 Volts or 0-60 VA ± 2% of full scale	1301-001	3
P101	Connector, Plug, Phenolic, 2 Contact, 15 Amp	1702-060	19
P200	Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	1702-015	21
P300	Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	1702-015	24
P400	Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	1702-015	27
P500	Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	1702-015	29
P700	Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	1702-015	32
P800	Plug, Precious Metal Contacts, 10 Amps, 12 Contacts	1702-014	33
P1001	Plug, Molded, Line Power Cord, 3 Conductor 7 ft. #18 AWG.	1702-027	
P1002	Connector, Plug, 32 Pin, 90° Male	1702-018	
P1003	Connector, Plug, 2 Pin, Male	1702-060	37
P1004	Connector, Plug, 32 Pin, 90° Female	1702-016	
Q200	Transistor, PNP, Germanium, 2N554	0202-007	21
Q201	Transistor, PNP, Germanium, 2N1193	0202-003	21
Q301	Transistor, NPN, Silicon, T1 480	0203-001	24
Q302	Transistor, PNP, Germanium, 2N658	0202-016	24
Q303	Transistor, NPN, Germanium, 2N1304	0201-003	24
Q401 & Q402	Transistor, PNP, Silicon, Audio, 2N327A	0204-001	27
Q403	Transistor, NPN, Germanium, 2N1308	0201-004	27
Q500	Transistor, PNP, Silicon, 2N2905	0204-003	30
Q1001** & Q1002**	Transistor, PNP, Germanium, Selected DTG 2400	0202-017	36
Q1003**	Transistor, PNP, Germanium, Selected DTG 2400	0202-018	36
Q1004**	Transistor, PNP, Germanium, Selected DTG 2400	0202-017	36
Q1005**	Transistor, PNP, Germanium, Selected DTG 2400	0202-018	36
Q1006** thru Q1009**	Transistor, PNP, Germanium, Selected DTG 2400	0202-017	36
Q1010**	Transistor, PNP, Germanium, Selected DTG 2400	0202-018	36
Q1011** thru Q1013**	Transistor, PNP, Germanium, Selected DTG 2400	0202-017	36

** Selected Component (See Notes 1 and 2)

Circuit Numbers	Description	Holt Part Number	Location Figure No.
Q1014**	Transistor, PNP, Germanium, Selected DTG 2400	0202-018	36
Q1101	Transistor, PNP, Germanium, 150 M W, 30 V, 2N1305	0202-009	38B
Q1102 thru Q1104	Transistor, PNP, Silicon, 700 MW, 25 V, 2N3638	0204-004	38B
Q1105	Transistor, PNP, Germanium, 150 MW, 30V, 2N1305	0202-009	38B
Q1106 thru Q1108	Transistor, PNP, Silicon, 700 MW, 25V, 2N3638	0204-004	38B
Q1201 thru Q1204	Transistor, PNP, Silicon, 700 MW, 25V, 2N3638	0202-004	39B
Q1205	Transistor, PNP, Germanium, 150 MW, 30V, 2N1305	0202-009	39B
Q1206 & Q1207	Transistor, PNP, Silicon, 700 MW, 25V, 2N3638	0202-004	39B
Q1301	Transistor, PNP, Germanium, 150 MW, 30V, 2N1305	0202-009	40
Q1302 & Q1303	Transistor, PNP, Silicon, 700 MW, 25V, 2N3638	0202-004	40
Q1304	Transistor, PNP, Germanium, 200 MW, 40V, 2N1193	0202-003	40
Q1305	Transistor, NPN, Silicon, 600 MW, 40V, T1484	0203-002	40
Q1601 & Q1602	Transistor, PNP, Germanium, 170 Watts, 140V, 2N2082	0202-015	43
Q1603**	Transistor, PNP, Germanium, Selected DTG 2400	0202-017	44
Q1604**	Transistor, PNP, Germanium, Selected DTG 2400	0202-018	44
Q1701** thru Q1704**	Transistor, PNP, Germanium, Selected DTG 2400	0202-017	45-46
R100	Resistor, Fixed, Wire Wound, 6 K Ohms, 50 Watts, ± 1%	0805-080	19
R101	Resistor, Fixed, Wire Wound, 500 Ohms, 8 Watts, ± 5%	0805-010	19
R102 & R103	Resistor, Fixed, Composition, 150 Ohms, 1/2 Watt, ± 10%	0801-034	20
R200	Resistor, Fixed, Metal Film, 26.7 K Ohms, 1/2 Watt, ± 1%	0804-074	22
R201	Resistor, Fixed, Metal Film, 182 Ohms, 1/4 Watt, ± 1%	0804-071	22
R202*	Resistor, Fixed, Metal Film, 16.9 K Ohms, 1/4 Watt, ± 1%	0804-076	22
R203	Resistor, Fixed, Metal Film, 4.75 K Ohms, 1/4 Watt (Part of Z201)	0804-075	22

* Factory Selected, Nominal Value Shown
** Selected Component (See Notes 1 and 2)

Circuit Number	Description	Holt Part Number	Location Figure No.
R204	Resistor, Fixed, Metal Film, 1 K Ohm, 1/4 Watt, ± 1%	0804-078	22
R205	Resistor, Fixed, Metal Film, 10 K Ohms, 1/4 Watt, ± 1%	0804-077	22
R206	Resistor, Fixed, Metal Film, 221 K Ohms, 1/2 Watt, ± 1%	0804-020	22
R207	Resistor, Fixed, Metal Film, 47.5 K Ohms, 1 Watt, ± 1%	0804-229	22
R208	Resistor, Fixed, Metal Film, 68.1 K Ohms, 1/2 Watt, ± 1%	0804-086	22
R209	Resistor, Fixed, Composition, 3.3 K Ohms, 1/2 Watt, ± 1%	0801-050	22
R210	Resistor, Fixed, Deposited Carbon, 10 M Ohms, 1/2 Watt, ± 1%	0803-129	22
R211	Resistor, Fixed, Metal Film, 825 K Ohms, 1/2 Watt, ± 1%	0804-203	22
R212	Resistor, Fixed, Metal Film, 1 K Ohm, 1/4 Watt, ± 1%	0804-078	22
R213	Resistor, Fixed, Metal Film, 33.2 K Ohms, 1 Watt, ± 1%	0804-228	23
R214	Resistor, Fixed, Composition, 22 K Ohms, 1 Watt, ± 10%	0801-140	22
R215	Resistor, Fixed, Composition, 1.8 K Ohms, 1 Watt, ± 10%	0801-127	23
R216	Resistor, Fixed, Composition, 33 K Ohms, 2 Watts, ± 10%	0801-181	22
R217	Resistor, Fixed, Metal Film, 47.5 K Ohms, 1 Watt, ± 1%	0804-229	23
R218	Resistor, Fixed, Metal Film, 68.1 K Ohms, 1/2 Watt, ± 1%	0804-086	23
R219	Resistor, Fixed, Metal Film, 562 K Ohms, 1/2 Watt, ± 1%	0804-200	23
R220	Resistor, Fixed, Metal Film, 182 Ohms, 1/2 Watt, ± 1%	0804-096	23
R221	Resistor, Fixed, Metal Film, 475 K Ohms, 1/2 Watt, ± 1%	0804-194	23
R222	Resistor, Fixed, Metal Film, 1 K Ohm, 1/4 Watt, ± 1%	0804-078	23
R223	Resistor, Fixed, Metal Film, 33.2 K Ohms, 1/2 Watt, ± 1%	0804-160	23
R224	Resistor, Fixed, Composition, 82 K Ohms, 1/2 Watt, ± 10%	0801-066	23
R225	Resistor, Fixed, Composition, 150 K Ohms, 1/2 Watt, ± 10%	0801-069	23
R226	Resistor, Fixed, Metal Film, 681 K Ohms, 1/2 Watt, ± 1%	0804-202	23
R227	Resistor, Fixed, Metal Film, 619 K Ohms, 1/2 Watt, ± 1%	0804-201	23
R228	Resistor, Fixed, Composition, 100 Ohms, 1/2 Watt, ± 10%	0801-032	23
R229	Resistor, Fixed, Wire Wound, 7.5 K Ohms, 5 Watts, ± 5%	0805-021	21
R230	Resistor, Fixed, Composition, 1.5 K Ohms, 1/2 Watt, ± 10%	0801-046	21
R231	Resistor, Fixed, Composition, 82 Ohms, 1/2 Watt, % 10%	0801-031	21
R232	Resistor, Fixed, Composition, 33 K Ohms, 1/2 Watt, ± 10%	0801-061	21
R233	Resistor, Fixed, Composition, 4.7 K Ohms, 1/2 Watt, ± 10%	0801-052	21
R234	Resistor, Fixed, Metal Film, 10 K Ohms, 1/4 Watt, ± 10%	0804-077	22

Circuit Number	Description	Holt Part Number	Location Figure No.
R439	Resistor, Fixed, Composition, 1 M Ohm, 1/2 Watt, ± 5%	0801-019	25
R440	Resistor, Fixed, Composition, 1 M Ohm, 1/2 Watt, ± 5%	0801-019	25
R441	Resistor, Fixed, Composition, 10 K Ohms, 1/2 Watt, ± 10%	0801-056	25
R442	Resistor, Fixed, Composition, 220 K Ohms, 1/2 Watt, ± 10%	0801-071	25
R443	Resistor, Fixed, Composition, 1.2 M Ohms, 1/2 Watt, ± 10%	0801-078	25
R444	Resistor, Fixed, Composition, 1 K Ohm, 1/2 Watt, ± 10%	0801-044	25
R445	Resistor, Fixed, Composition, 10 M Ohms, 1/2 Watt, ± 10%	0801-089	25
R446	Resistor, Fixed, Composition, 33 K Ohms, 1/2 Watt, ± 10%	0801-061	25
R447	Resistor, Fixed, Composition, 39 K Ohms, 1/2 Watt, ± 10%	0801-062	25
R448	Resistor, Variable, Composition, 50 Ohms, 2 Watts, ± 10%	0806-001	25
R449	Resistor, Fixed, Composition, 12 Ohms, 1/2 Watt, ± 10%	0801-021	25
R450	Resistor, Fixed, Wire Wound, 30 Ohms, 1/4 Watt, 1%	0802-158	
R451	Resistor, Fixed, Composition, 1 M Ohm, 1/2 Watt, ± 5%	0801-019	25
R500	Resistor, Fixed, Metal Film, 16.9 K Ohms, 1/2 Watt, ± 1%	0804-149	29
R501	Resistor, Fixed, Metal Film, 24.9 K Ohms, 1/2 Watt, ± 1%	0804-154	29
R502	Resistor, Fixed, Metal Film, 453 Ohms, 1/2 Watt, ± 1%	0804-106	29
R503	Resistor, Fixed, Metal Film, 39.2 K Ohms, 1/4 Watt, ± 1%	0804-087	29
R504	Resistor, Fixed, Metal Film, 4.32 K Ohms, 1/4 Watt, ± 1%	0804-088	29
R505	Resistor, Fixed, Composition, 100 K Ohms, 1/2 Watt, ± 10%	0801-067	29
R506	Resistor, Fixed, Metal Film, 1 M Ohm, 1/2 Watt, ± 1%	0804-206	29
R507	Resistor, Fixed, Metal Film, 1.5 K Ohms, 1/2 Watt, ± 1%	0804-121	29
R508	Resistor, Fixed, Composition, 47 K Ohms, 1/2 Watt, ± 10%	0801-063	29
R509	Resistor, Fixed, Composition, 10 M Ohms, 1/2 Watt, ± 10%	0801-089	29
R510	Resistor, Fixed, Composition, 10 M Ohms, 1/2 Watt, ± 10%	0801-089	29
R511	Resistor, Fixed, Metal Film, 47.5 K Ohms, 1/2 Watt, ± 1%	0804-162	29
R512	Resistor, Fixed, Metal Film, 1 M Ohm, 1/2 Watt, ± 1%	0804-206	29
R513	Resistor, Fixed, Metal Film, 3.92 K Ohms, 1/2 Watt, ± 1%	0804-132	29
R514	Resistor, Variable, Wire Wound, 10 K Ohms, 1/5 Watt, ± 10%	0806-058	29
R515	Resistor, Fixed, Composition, 8.2 K Ohms, 1/2 Watt, ± 10%	0801-055	29
R516	Resistor, Fixed, Composition, 10 K Ohms, 1 Watt, ± 10%	0801-136	29
R517	Resistor, Fixed, Composition, 1 M Ohm, 1/2 Watt, ± 5%	0801-019	29

Circuit Number	Description	Holt Part Number	Location Figure No.
R518	Resistor, Fixed, Composition, 1 M Ohm, 1/2 Watt, ± 5%	0801-019	29
R519	Resistor, Fixed, Composition, 330 Ohms, 1 Watt, ± 10%	0801-118	29
R520	Resistor, Fixed, Composition, 27 K Ohms, 1 Watt, ± 10%	0801-141	29
R521	Resistor, Fixed, Composition, 27 K Ohms, 1 Watt, ± 10%	0801-141	29
R522 thru R525	Resistor, Fixed, Composition, 820 K Ohms, 1/2 Watt, ± 10%	0801-077	29
R526 & R527	Resistor, Fixed, Composition, 100 K Ohms, 1/2 Watt, ± 10%	0801-067	29
R528	Resistor, Fixed, Composition, 680 Ohms, 1 Watt, ± 10%	0801-122	29
R529 & R530	Resistor, Fixed, Composition, 1.8 K Ohms, 1/2 Watt, ± 10%	0801-047	29
R531 & R532	Resistor, Fixed, Wire Wound, 30 K Ohms, 12 Watts, ± 5%	0805-043	29
R534 & R535	Resistor, Fixed, Composition, 1 M Ohm, 1/2 Watt, ± 5%	0801-019	29
R537 & R538	Resistor, Fixed, Composition, 100 K Ohms, 2 Watts, ± 10%	0801-185	29
R539 & R540	Resistor, Fixed, Composition, 220 K Ohms, 1/2 Watt, ± 10%	0801-071	
R541 & R542	Resistor, Fixed, Composition, 220 Ohms, 1 Watt, ± 10%	0801-116	
R543	Resistor, Fixed, Wire Wound, 100 Ohms, 8 Watts, ± 5%	0805-006	30
R544	Resistor, Fixed, Wire Wound, 100 Ohms, 8 Watts, ± 5%	0805-006	30
R545	Resistor, Fixed, Composition, 15 K Ohms, 1/2 Watt, ± 10%	0801-058	30
R546	Resistor, Fixed, Composition, 47 K Ohms, 1/2 Watt, ± 10%	0801-063	30
R547	Resistor, Fixed, Composition, 15 K Ohms, 1/2 Watt, ± 10%	0801-058	30
R548	Resistor, Fixed, Composition, 10 K Ohms, 1/2 Watt, ± 10%	0801-056	30
R549	Resistor, Fixed, Composition, 47 K Ohms, 1/2 Watt, ± 10%	0801-063	30
R550	Resistor, Fixed, Composition, 2.2 K Ohms, 1/2 Watt, ± 10%	0801-048	30
R551	Resistor, Fixed, Metal Film, 47.5 K Ohms, 1/2 Watt, ± 1%	0804-162	30
R552	Resistor, Fixed, Metal Film, 825 K Ohms, 1/2 Watt, ± 1%	0804-203	30
R553	Resistor, Fixed, Deposited Carbon, 30.1 K Ohms, 1/2 Watt, ± 1%	0804-159	30
R554 & R555	Resistor, Variable, Wire Wound, 100 K Ohms, 1/5 Watt, ± 20%	0806-157	30
R600 thru R607	Resistor, Fixed, Wire Wound, 20 K Ohms, ± .01%	0802-050	31

Circuit Numbers	Description	Holt Part Number	Location Figure No.
R608	Resistor, Fixed, Wire Wound, 19.8 K Ohms, ± .01%	0802-049	31
R609 thru R616	Resistor, Fixed, Wire Wound, 2 K Ohms, ± .01%	0802-047	31
R617	Resistor, Fixed, Wire Wound, 1.8 K Ohms, ± .01%	0802-046	31
R618 thru R627	Resistor, Fixed, Wire Wound, 200 Ohms, ± .01%	0802-043	31
R628 thru R636	Resistor, Fixed, Wire Wound, 20 Ohms, ± .01%	0802-042	31
R637 thru R645	Resistor, Fixed, Wire Wound, 2 Ohms, ± .01%	0802-041	31
R646	Resistor, Variable, Wire Wound, 100 Ohms, 3.5 Watts, ± 1%	0806-032	3-31
R647	Resistor, Fixed, Metal Film, 1 K Ohm, 1/2 Watt, ± 1%	0804-116	31
R648 thru R652	Resistor, Fixed, Composition, 1.8 K Ohms, 1/2 Watt, ± 10%	0801-047	31
R653 & R654	Resistor, Fixed, Composition, 1 K Ohm, 1/2 Watt, ± 10%	0801-044	31
R655 thru R657	Resistor, Fixed, Composition, 1.8 K Ohms, 1/2 Watt, ± 10%	0801-047	31
R658 & R659	Resistor, Fixed, Composition, 6.8 K Ohms, 1/2 Watt, ± 10%	0801-054	31
R660	Resistor, Fixed, Composition, 18 K Ohms, 1/2 Watt, ± 5%	0801-006	31
R661	Resistor, Fixed, Metal Film, 1.5 K Ohms, 1/2 Watt, ± 1%	0804-121	31
R662	Resistor, Fixed, Wire Wound, 25.9 Ohms, ± .01%	0802-152	31
R663	Resistor, Fixed, Wire Wound, 100 Ohms, 1/2 Watt, ± .01%	0802-150	31
R700	Resistor, Fixed, Wire Wound, 178.5 Ohms, ± .01%	0802-269	32
R701	Resistor, Fixed, Wire Wound, 10 Ohms, 1/3 Watt, ± 1%	0802-173	32
R702	Resistor, Fixed, Metal Film, 100 K Ohms, 1/2 Watt, ± 1%	0804-170	32
R703	Resistor, Fixed, Wire Wound, 10 K Ohms, ± .01%	0802-270	32
R704	Resistor, Variable, Cermet, 10 Ohms, 1/4 Watt, ± 10%	0806-062	32
R705	Resistor, Fixed, Wire Wound, 10 K Ohms, ± .01%	0802-270	32
R706	Resistor, Fixed, Metal Film, 619 K Ohms, 1/2 Watt, ± 1%	0804-201	32
R707	Resistor, Fixed, Metal Film, 221 K Ohms, 1/2 Watt, ± 1%	0804-181	32
R708	Resistor, Fixed, Metal Film, 162 K Ohms, 1/2 Watt, ± 1%	0804-176	32
R709	Resistor, Fixed, Metal Film, 10 K Ohms, 1/2 Watt, ± 1%	0804-142	32
R710	Resistor, Fixed, Deposited Carbon, 4.32 M Ohms, 1/2 Watt, ± 1%	0803-127	32

Circuit Number	Description	Holt Part Number	Location Figure No.
R711	Resistor, Fixed, Metal Film, 619 Ohms, 1/2 Watt, ± 1%	0804-110	32
R712	Resistor, Fixed, Metal Film, 511 Ohms, 1/2 Watt, ± 1%	0804-108	32
R713	Resistor, Fixed, Metal Film, 10 K Ohms, 1 Watt, ± 1%	0804-227	32
R714	Resistor, Fixed, Metal Film, 100 K Ohms, 1/2 Watt, ± 1%	0804-170	32
R715	Resistor, Fixed, Metal Film, 150 K Ohms, 1/2 Watt, ± 1%	0804-175	32
R716	Resistor, Fixed, Metal Film, 10 K Ohms, 1 Watt, ± 1%	0804-227	32
R717	Resistor, Fixed, Metal Film, 332 Ohms, 1/2 Watt, ± 1%	0804-103	32
R718	Resistor, Fixed, Metal Film, 100 K Ohms, 1/2 Watt, ± 1%	0804-170	32
R719	Resistor, Fixed, Metal Film, 162 K Ohms, 1/2 Watt, ± 1%	0804-176	32
R720*	Resistor, Fixed, Metal Film, 8.06 K Ohms, 1/2 Watt, ± 1%	0804-072	32
R721	Resistor, Variable, Wire Wound, 1 K Ohm, 10 Turn, ± 5%	0806-048	32
R722	Resistor, Fixed, Composition, 330 Ohms, 1/2 Watt, ± 10%	0801-038	32
R723	Resistor, Fixed, Metal Film, 1.18 K Ohms, 1/2 Watt, ± 1%	0804-118	32
R724	Resistor, Fixed, Wire Wound, 10 K Ohms, 8 Watts, ± 5%	0805-022	32
R725	Resistor, Fixed, Metal Film, 1 K Ohm, 1/2 Watt, ± 1%	0804-116	32
R726	Resistor, Fixed, Metal Film, 130 K Ohms, 1/2 Watt, ± 1%	0804-174	32
R727	Resistor, Fixed, Wire Wound, 10 K Ohms, ± .01%	0802-270	32
R728	Resistor, Fixed, Wire Wound, 445 Ohms, ± .01%	0802-272	32
R729	Resistor, Fixed, Wire Wound, 10 K Ohms, ± .01%	0802-270	32
R800	Resistor, Fixed, Metal Film, 332 Ohms, 1/2 Watt, ± 1%	0804-103	33
R801	Resistor, Fixed, Metal Film, 909 Ohms, 1/2 Watt, ± 1%	0804-114	33
R1001 thru R1005	Resistor, Fixed, Composition, 100 K Ohms, 1/2 Watt, ± 10%	0801-067	35
R1006	Resistor, Fixed, Wire Wound, 2.5 K Ohms, 12 Watts, ± 5%	0805-035	37
R1007	Resistor, Fixed, Composition, 100 K Ohms, 1/2 Watt, ± 10%	0801-067	35
R1008	Resistor, Fixed, Wire Wound, 750 Ohms, 8 Watts, ± 5%	0805-011	35
R1009	Resistor, Fixed, Composition, 100 K Ohms, 1/2 Watt, ± 10%	0801-067	35
R1010	Resistor, Fixed, Wire Wound, 750 Ohms, 8 Watts, ± 5%	0805-011	35
R1011	Resistor, Fixed, Composition, 390 K Ohms, 1/2 Watt, ± 10%	0801-074	35
R1012 thru R1015	Resistor, Fixed, Wire Wound, 700 Ohms, 8 Watts, ± 5%	0805-077	35

* Factory Selected, Nominal Value Shown

Circuit Number	Description	Holt Part Number	Location Figure No.
R1016	Resistor, Fixed, Wire Wound, 15 K Ohms, 12 Watts, ± 5%	0805-041	34
R1017	Resistor, Fixed, Composition, 220 K Ohms, 1/2 Watt, ± 10%	0801-071	35
R1018 thru R1020	Resistor, Fixed, Wire Wound, 500 Ohms, 8 Watts, ± 5%	0805-010	35
R1021	Resistor, Fixed, Composition, 560 K Ohms, 1 Watt, ± 10%	0801-210	35
R1022 thru R1024	Resistor, Fixed, Composition, 150 Ohms, 1/2 Watt, ± 10%	0801-034	36
R1025	Resistor, Fixed, Wire Wound, 1.5 K Ohms, 10 Watts, ± 1%	0805-079	35
R1026	Resistor, Fixed, Composition, 150 Ohms, 1/2 Watt, ± 10%	0801-034	36
R1027	Resistor, Fixed, Wire Wound, 100 Ohms, 50 Watts, ± 1%	0805-078	35
R1028*	Resistor, Fixed, Composition, 820 Ohms, 2 Watts, ± 10%	0801-171	35
R1101	Resistor, Fixed, Wire Wound, 750 Ohms, 8 Watts, ± 5%	0805-011	38A
R1102	Resistor, Fixed, Wire Wound, 1.5 Ohms, 2 Watts, ± 5%	0802-274	38A
R1103	Resistor, Fixed, Composition, 1.2 K Ohms, 1/2 Watt, ± 10%	0801-045	38A
R1104	Resistor, Fixed, Wire Wound, 15 K Ohms, 8 Watts, ± 5%	0805-023	38A
R1105	Resistor, Fixed, Wire Wound, 10 K Ohms, 8 Watts, ± 5%	0805-022	38A
R1106	Resistor, Fixed, Composition, 8.2 K Ohms, 1/2 Watt, ± 10%	0801-055	38A
R1107	Resistor, Fixed, Composition, 56 K Ohms, 1/2 Watt, ± 10%	0801-064	38A
R1108	Resistor, Fixed, Composition, 2.2 K Ohms, 1/2 Watt, ± 10%	0801-048	38A
R1109*	Resistor, Fixed, Wire Wound, 2.8 K Ohms, 2 Watts, ± 1%	0803-255	38A
R1110	Resistor, Fixed, Wire Wound, 17.5 K Ohms, 5 Watts, ± 1%	0802-245	38A
R1111	Resistor, Fixed, Wire Wound, 17.5 K Ohms, 5 Watts, ± 1%	0802-245	38A
R1112	Resistor, Fixed, Wire Wound, 1.8 K Ohms, 1/4 Watt, ± 1%	0802-244	38A
R1113	Resistor, Variable, Cermet, 24 Turns, 5 K Ohms, 1 Watt	0806-049	38A
R1114*	Resistor, Fixed, Wire Wound, 50 Ohms, 1/4 Watt, ± 1%	0802-160	38A
R1115*	Resistor, Fixed, Wire Wound, 2.3 K Ohms, 1/4 Watt, 0.1%	0802-261	38A
R1118	Resistor, Fixed, Wire Wound, 750 Ohms, 8 Watts, ± 5%	0805-011	38A
R1119	Resistor, Fixed, Wire Wound, 15 K Ohms, 8 Watts, ± 5%	0805-023	38A
R1120	Resistor, Fixed, Wire Wound, 1.5 Ohms, 2 Watts, ± 5%	0802-274	38A
R1121	Resistor, Fixed, Composition, 1.2 K Ohms, 1/2 Watt, ± 10%	0801-045	38A
R1122	Resistor, Fixed, Composition, 20 K Ohms, 2 Watts, ± 10%	0801-211	38A

* Factory Selected, Nominal Value Shown

Circuit Number	Description	Holt Part Number	Location Figure No.
R1123	Resistor, Fixed, Composition, 8.2 K Ohms, 1/2 Watt, ± 10%	0801-055	38A
R1124	Resistor, Fixed, Composition, 56 K Ohms, 1/2 Watt, ± 10%	0801-064	38A
R1125	Resistor, Fixed, Composition, 2.2 K Ohms, 1/2 Watt, ± 10%	0801-048	38A
R1126*	Resistor, Fixed, Wire Wound, 2.72 K Ohms, 2 Watts, ± 1%	0802-254	38A
R1127	Resistor, Fixed, Wire Wound, 17.5 K Ohms, 5 Watts, 1%	0802-245	38A
R1128	Resistor, Fixed, Composition, 120 Ohms, 1/2 Watt, ± 10%	0801-033	38A
R1201	Resistor, Fixed, Wire Wound, 500 Ohms, 8 Watts, ± 5%	0805-010	39A
R1202	Resistor, Fixed, Wire Wound, 2.7 Ohms, 2 Watts, ± 10%	0802-126	39A
R1203	Resistor, Fixed, Composition, 1.2 K Ohms, 1/2 Watt, ± 10%	0801-045	39A
R1204	Resistor, Fixed, Composition, 120 Ohms, 1/2 Watt, ± 10%	0801-033	39A
R1205	Resistor, Fixed, Wire Wound, 25 K Ohms, 12 Watts, ± 5%	0805-076	39A
R1206 & R1207	Resistor, Fixed, Composition, 68 K Ohms, 2 Watts, ± 10%	0801-184	39A
R1208	Resistor, Fixed, Composition, 8.2 K Ohms, 1/2 Watt, ± 10%	0801-055	39A
R1209	Resistor, Fixed, Composition, 120 K Ohms, 1 Watt, ± 10%	0801-149	39A
R1210	Resistor, Fixed, Composition, 2.2 K Ohms, 1/2 Watt, ± 10%	0801-048	39A
R1211*	Resistor, Fixed, Wire Wound, 2.48 K Ohms, 2 Watts, ± 1%	0802-252	39A
R1212	Resistor, Fixed, Wire Wound, 27.5 K Ohms, 10 Watts, ± 1%	0802-249	39A
R1213	Resistor, Fixed, Wire Wound, 700 Ohms, 8 Watts, ± 5%	0805-077	39A
R1214	Resistor, Fixed, Wire Wound, 1.5 Ohms, 2 Watts, ± 5%	0802-274	39A
R1215 & R1216	Resistor, Fixed, Composition, 150 K Ohms, 2 Watts, ± 10%	0801-087	39A
R1217	Resistor, Fixed, Composition, 180 K Ohms, 2 Watts, ± 10%	0801-188	39A
R1218 & R1219	Resistor, Fixed, Composition, 4.7 K Ohms, 1/2 Watt, ± 10%	0801-052	39A
R1220	Resistor, Fixed, Composition, 180 K Ohms, 2 Watts, ± 10%	0801-188	39A
R1221*	Resistor, Fixed, Wire Wound, 2.64 K Ohms, 2 Watts, ± 1%	0802-241	39A
R1222	Resistor, Fixed, Wire Wound, 47 K Ohms, 10 Watts, ± 1%	0802-248	39A
R1223	Resistor, Fixed, Composition, 1.5 K Ohms, 1/2 Watt, ± 10%	0801-046	39A
R1301	Resistor, Fixed, Wire Wound, 300 Ohms, 12 Watts, ± 5%	0805-073	40
R1302	Resistor, Fixed, Wire Wound, 2.5 K Ohms, 8 Watts, ± 5%	0805-016	40
R1303	Resistor, Fixed, Wire Wound, 1.5 Ohms, 2 Watts, ± 5%	0802-274	40
R1304 & R1305	Resistor, Fixed, Composition, 180 K Ohms, 2 Watts, ± 10%	0801-188	40

* Factory Selected, Nominal Value Shown

Circuit Number	Description	Holt Part Number	Location Figure No.
R1306	Resistor, Fixed, Composition, 220 K Ohms, 2 Watts, ± 10%	0801-189	40
R1307 & R1308	Resistor, Fixed, Composition, 4.7 K Ohms, 1/2 Watt, ± 10%	0801-052	40
R1309	Resistor, Fixed, Composition, 220 K Ohms, 2 Watts, ± 10%	0801-189	40
R1310	Resistor, Fixed, Composition, 27 K Ohms, 1/2 Watt, ± 10%	0801-060	40
R1311	Resistor, Fixed, Wire Wound, 2.64 K Ohms, 2 Watts, ± 1%	0802-241	40
R1312	Resistor, Fixed, Wire Wound, 55 K Ohms, 10 Watts, ± 1%	0802-239	40
R1313	Resistor, Fixed, Composition, 82 Ohms, 1/2 Watt, ± 10%	0801-031	40
R1314	Resistor, Fixed, Composition, 1.5 K Ohms, 1/2 Watt, ± 10%	0801-046	40
R1315	Resistor, Fixed, Composition, 470 Ohms, 1/2 Watt, ± 10%	0801-040	40
R1316	Resistor, Fixed, Composition, 10 Ohms, 1/2 Watt, ± 10%	0801-020	40
R1401 thru R1415	Resistor, Fixed, Composition, 390 K Ohms, 1 Watt, ± 10%	0801-151	41
R1601 & R1602	Resistor, Fixed, Wire Wound, 0.1 Ohms, 5 Watts, ± 5%	0805-074	43
R1603	Resistor, Fixed, Wire Wound, 300 Ohms, 12 Watts, ± 5%	0805-073	43
R1604	Resistor, Fixed, Composition, 47 Ohms, 1/2 Watt, ± 10%	0801-028	43
R1701 thru R1704	Resistor, Fixed, Wire Wound, 300 Ohms, 12 Watts, ± 5%	0805-073	45
RT200	Part of Z200		
RT201	Part of Z200		
S100	Switch, Bat Handle, Toggle, SPST, 3 Amp, 250 Volts	1103-001	3
S101	Switch, Bat Handle, Toggle, 3PDT, 10 Amp, 250 Volts	1103-008	3
S102	Switch, Button, Non-locking, SPDT, 3 Amp, 120 Volts	1102-002	3
S103	Switch, Range	1101-039	3
S200	Switch, Rotary, 7 Position, 5 Section	1101-007	3-21
S201	Switch, Rotary, 11 Position, 4 Section	1101-011	3-21
S600	Switch, 100 Volt	1101-013	3
S601	Switch, 10 Volt	1101-012	3
S602	Switch, 1 Volt	1101-008	3
S603	Switch, 100 MV	1101-009	3
S604	Switch, 10 MV	1101-010	3
S1601	Thermoswitch, 150° F., SPST, Normally Closed	0405-002	43

Circuit Number	Description	Holt Part Number	Location Figure No.
T100	Transformer, Output	52731A	20
T101	Transformer, Current	52703	20
T102	Transformer, Output, Low Frequency	52182	19
T600	Transformer, High Voltage, High Frequency	52733	31
T601	Transformer, Ratio	1604-001	31
T1001	Transformer, Filament	1602-009	35
T1002	Transformer, Power	1601-012	35
TB1001	Terminal Strip, Barrier, 8 Terminals	1803-069	37
V200***	Tube, Electron, 12AX7/ECC83	0102-016	21
V201	Tube, Electron, 7199	0102-004	21
V202***	Tube, Electron, 12AX7/ECC83	0102-016	21
V203	Tube, Electron, CV4014	0101-014	21
V204	Tube, Electron, 6AQ5	0101-006	21
V401	Tube, Electron, 6267	0102-006	27
V402	Tube, Electron, 12AX7/ECC83	0102-016	27
V403	Tube, Electron, 12AT7/ECC81	0102-017	27
V404	Tube, Electron, 7199	0102-004	27
V501***	Tube, Electron, 7199	0102-004	29
V502	Tube, Electron, 7199	0102-004	29
V503	Tube, Electron, 12AU7/ECC82	0102-015	29
V504***	Tube, Electron, 12BH7	0102-008	29
V505	Tube, Electron, 12AX7/ECC83	0102-016	29
V506 & V507	Tube, Electron, KT88	0103-017	20
V701	Tube, Electron, CV4014	0101-014	32
V702 & V703	Tube, Electron, 6DK6	0101-003	32
V704	Tube, Electron, 5687	0102-007	32
Z200	Thermistor Oven Assembly (Temp. 55° C., 6.3 VDC) consisting of:	82375	21
	Thermistor, RT200, BA51V3, 100 K Ohms, ± 20%	0403-002	
	Thermistor, RT201, BA44V1, 40 K Ohms, ± 20%	0403-001	

*** Factory Selected for Minimum Microphonics and Noise

Circuit Reference	Description	Holt Part Number	Location Figure No.
Z401	Recovery Module	52702	27
Z800	Control Module	82699A	33

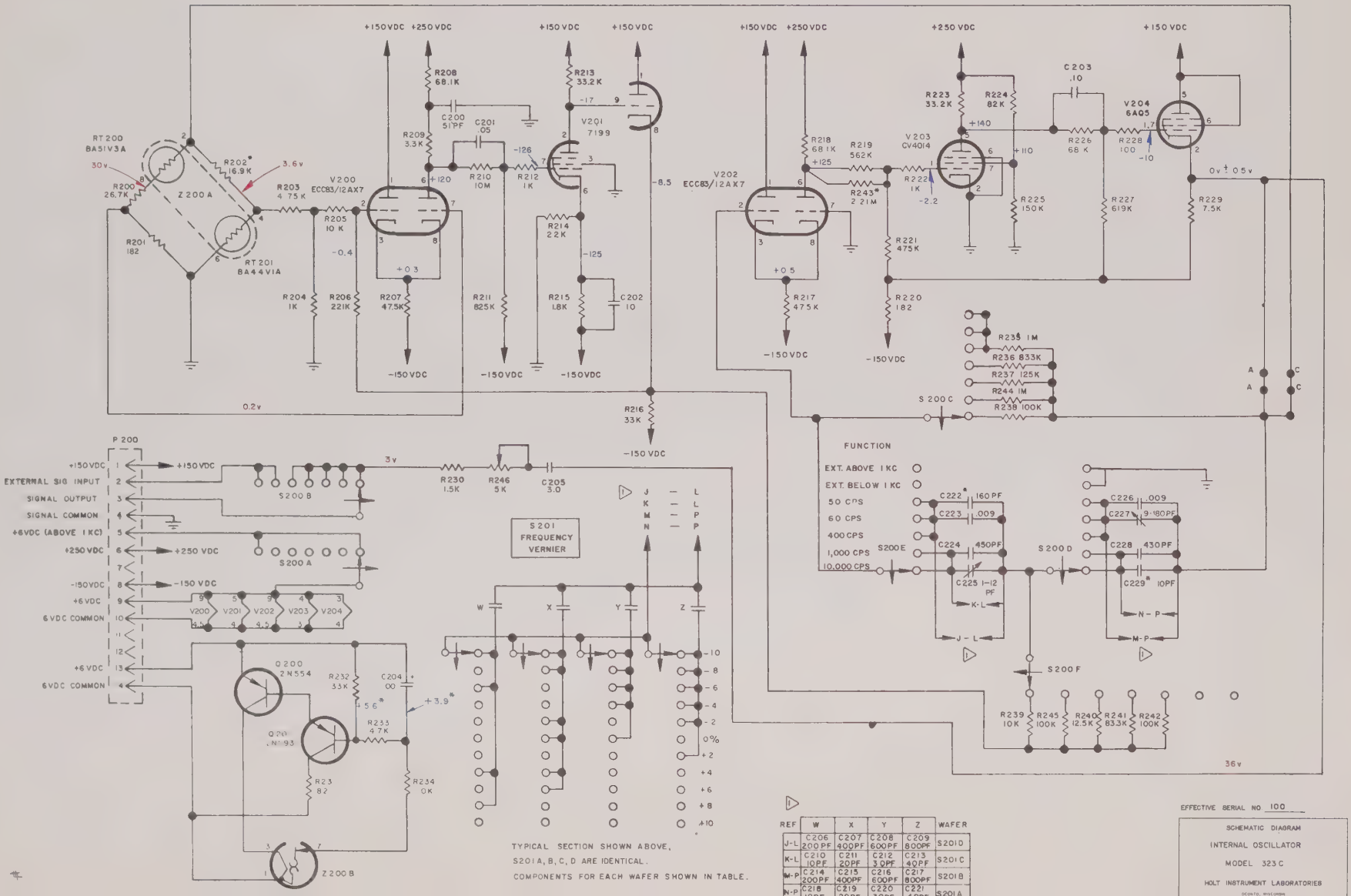
Note 1 - Part No. 0202-017 is selected for $60 \leq h_{fe} \leq 300$ at 25 VDC and 100 MADC.

Note 2 - Part No. 0202-018 is selected for $30 \leq h_{fe} \leq 60$ at 25 VDC and 100 MADC.

NOTE

*FACTORY SELECTED VALUE, TYPICAL VALUE INDICATED.
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN MICROFARADS
UNLESS OTHERWISE SPECIFIED.

* OVEN HEATER "ON"

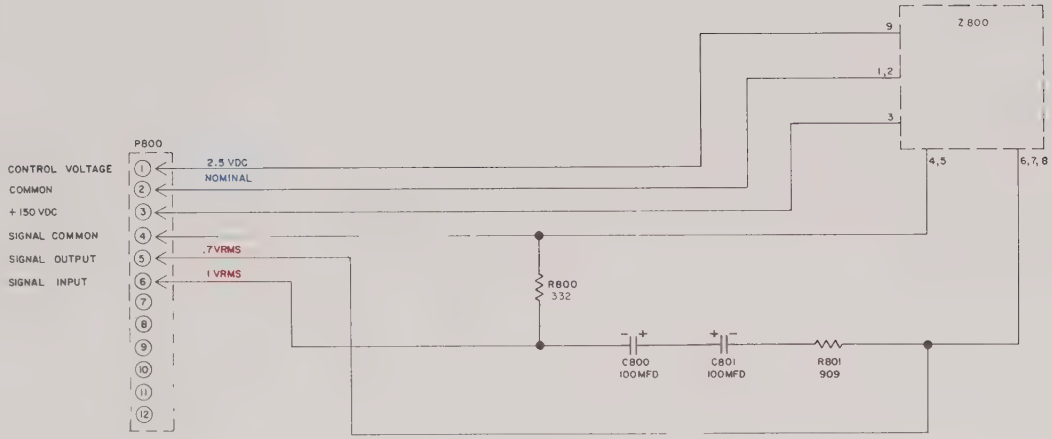


TYPICAL SECTION SHOWN ABOVE,
S201A, B, C, D ARE IDENTICAL.
COMPONENTS FOR EACH WAFER SHOWN IN TABLE.

REF	W	X	Y	Z	WAFER
J-L	C206 200 PF	C207 400PF	C208 600PF	C209 800PF	S201D
K-L	C210 10PF	C211 20PF	C212 30PF	C213 40PF	S201C
M-P	C214 200PF	C215 400PF	C216 600PF	C217 800PF	S201B
N-P	C218 10PF	C219 20PF	C220 30PF	C221 40PF	S201A

EFFECTIVE SERIAL NO 100

SCHEMATIC DIAGRAM
INTERNAL OSCILLATOR
MODEL 323C
HOLT INSTRUMENT LABORATORIES
OCONTO, WISCONSIN



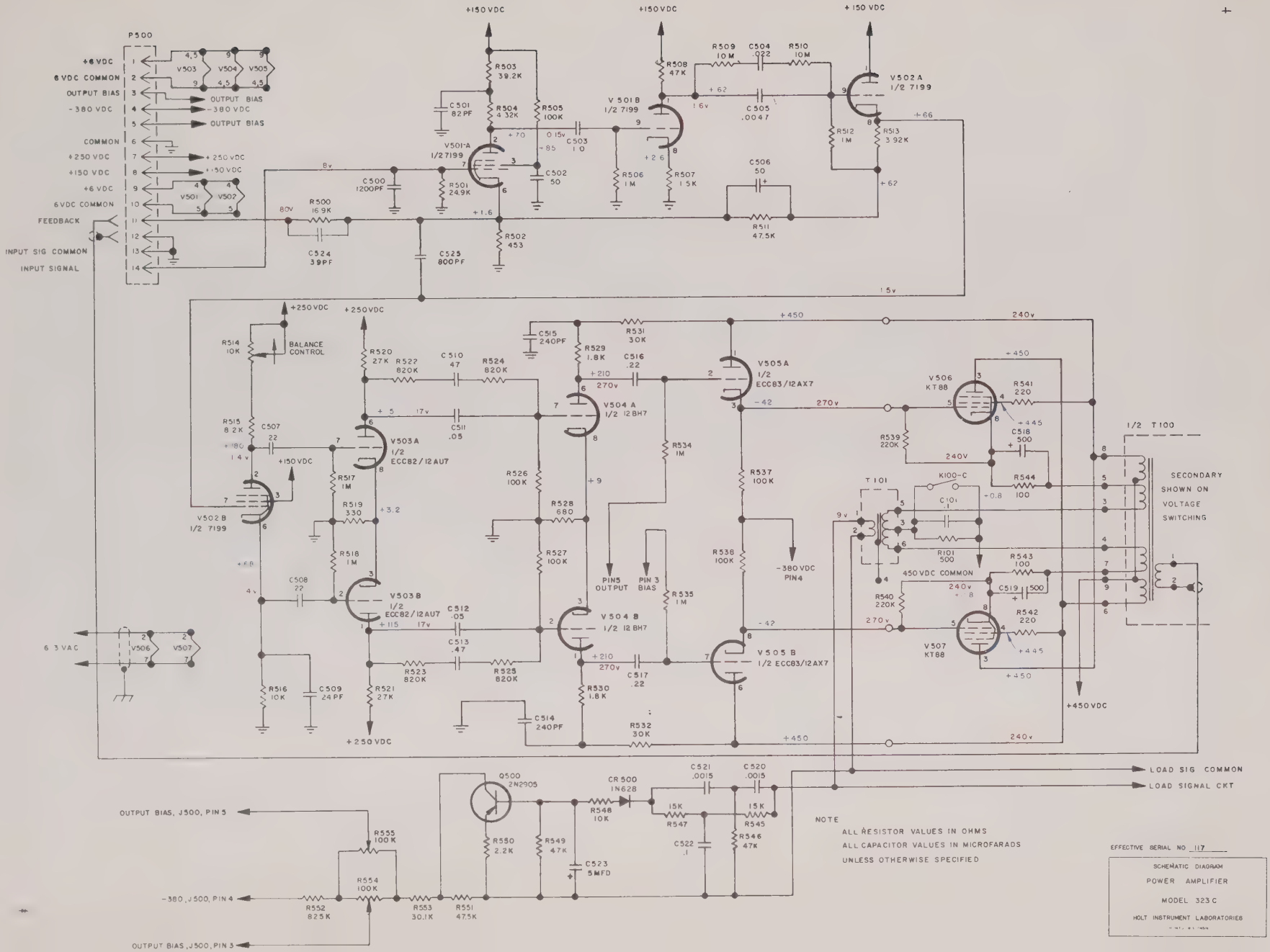
EFFECTIVE SERIAL NO 100

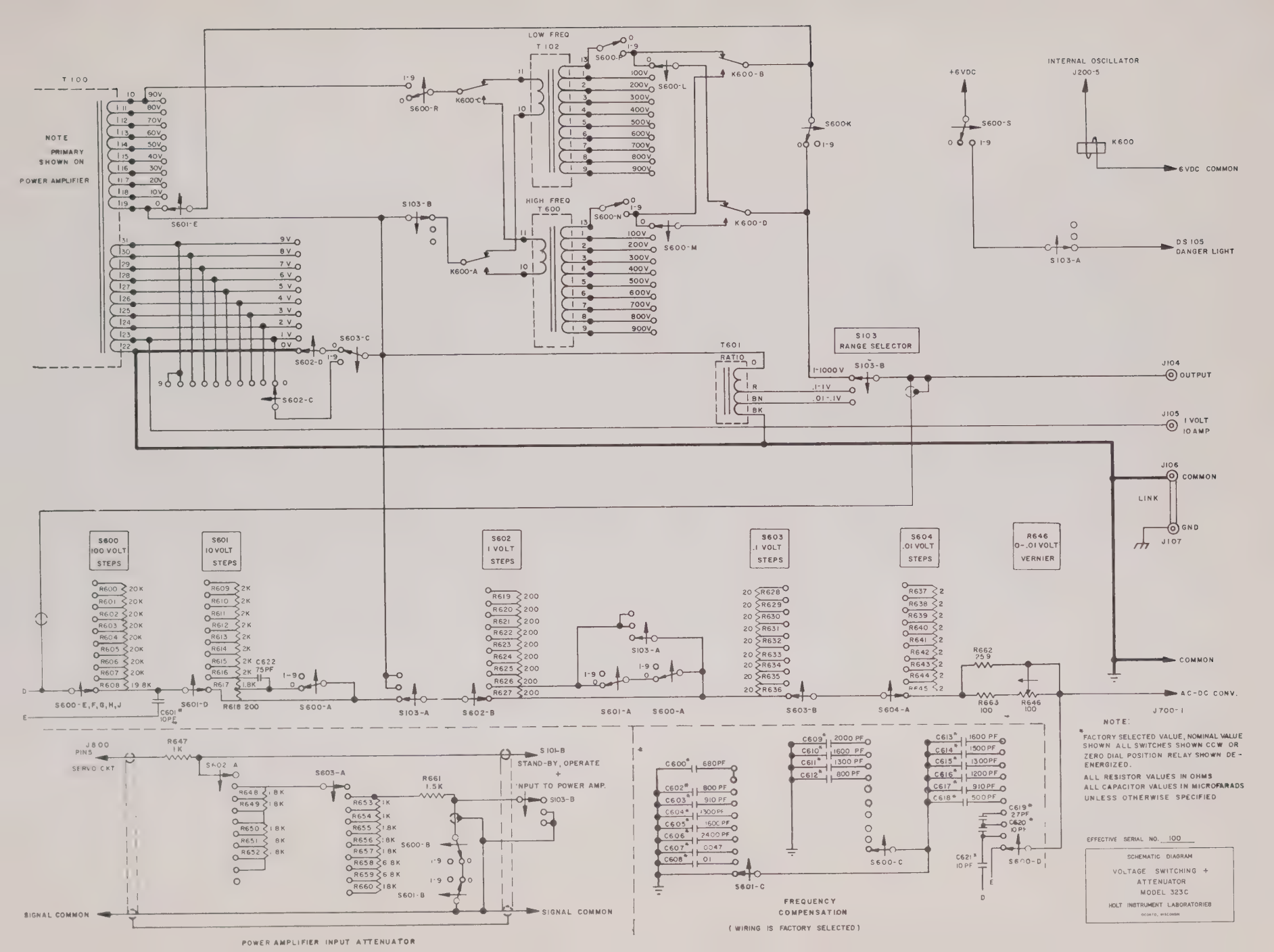
SCHEMATIC DIAGRAM

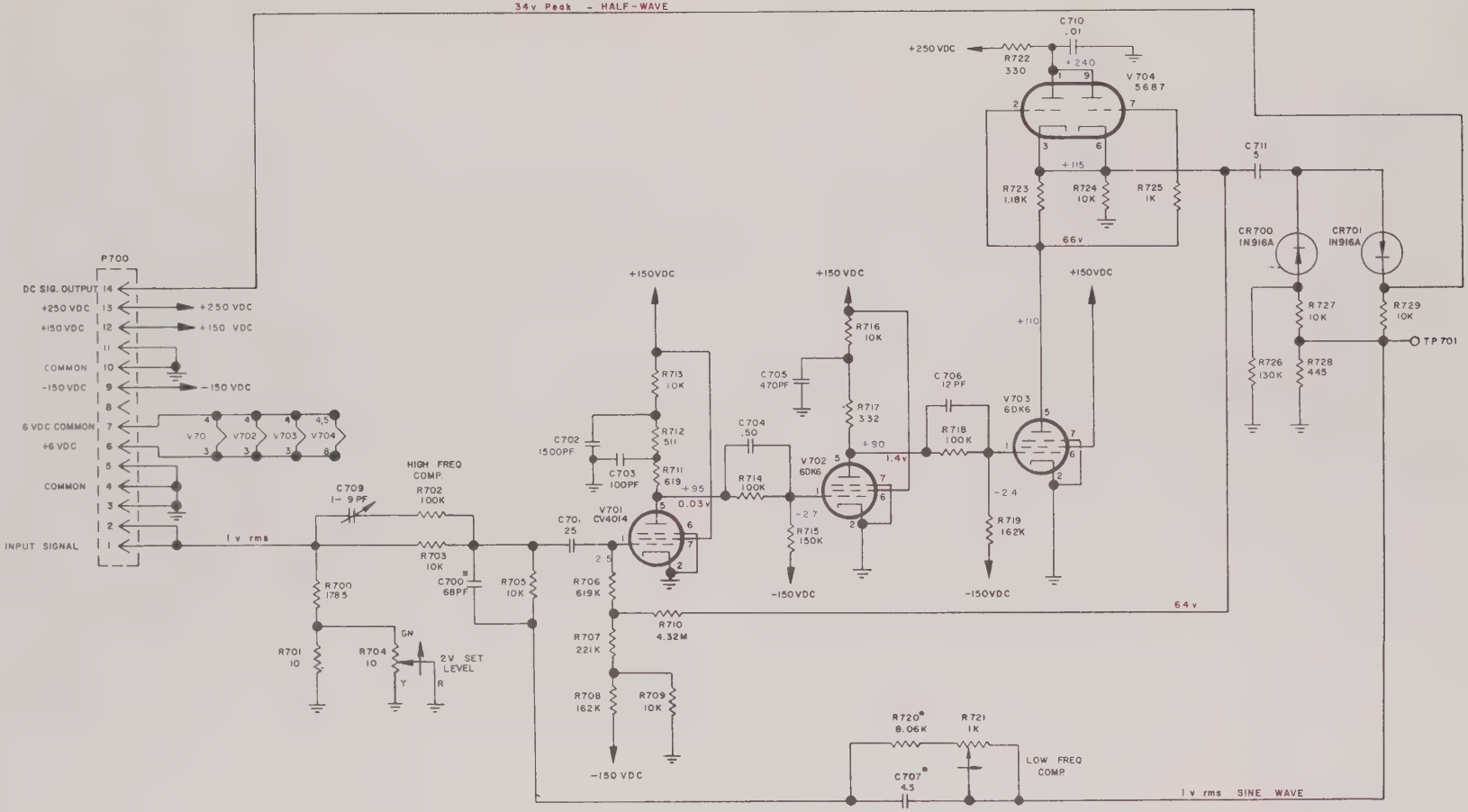
INPUT REGULATOR

MODEL 323C

HOLT INSTRUMENT LABORATORIES


P500
+6 VDC
6 VDC COMMON
OUTPUT BIAS
-380 VDC
OUTPUT BIAS
COMMON
+250 VDC
+150 VDC
+6 VDC
6 VDC COMMON
FEEDBACK
INPUT SIG COMMON
INPUT SIGNAL
V503
V504
V505
V501
V502
+150 VDC
R503 39.2K
C501 82PF
R504 4.32K
R505 100K
V501-A 1/2 7199
C500 1200PF
R501 24.9K
C502 50
C503 1.0
R500 16.9K
C524 39PF
C525 800PF
R502 453
V501-B 1/2 7199
R508 47K
R509 10M
C504 .022
R510 10M
C505 .0047
R506 1M
R507 1.5K
V502-A 1/2 7199
R512 1M
R513 3.92K
C506 50
R511 47.5K
+250 VDC
R514 10K
BALANCE CONTROL
R520 27K
R522 820K
C510 47
R524 820K
C515 240PF
R529 1.8K
C516 .22
R531 30K
V504-A 1/2 12BH7
C511 .05
R515 8.2K
C507 22
V503-A 1/2 ECC82/12AU7
R517 1M
R519 330
R526 100K
R528 680
V502-B 1/2 7199
R518 1M
C508 22
V503-B 1/2 ECC82/12AU7
C512 .05
C513 .47
R523 820K
R525 820K
R527 100K
V504-B 1/2 12BH7
R516 10K
C509 24PF
R521 27K
C514 240PF
R530 1.8K
R532 30K
+450
240v
V505-A 1/2 ECC83/12AX7
C517 .22
V505-B 1/2 ECC83/12AX7
R534 1M
R537 100K
R538 100K
R535 1M
PIN5 OUTPUT
PIN 3 BIAS
-380 VDC PIN4
V506 KT88
R541 220
C518 500
R539 220K
R544 100
K100-C
C101 .1
T101
R101 500
R543 100
450 VDC COMMON
C519 500
R540 220K
R542 220
V507 KT88
+450 VDC
1/2 T100
SECONDARY SHOWN ON VOLTAGE SWITCHING
6.3 VAC
V506
V507
LOAD SIG COMMON
LOAD SIGNAL CKT
Q500 2N2905
CR 500 IN628
C521 .0015
C520 .0015
R548 10K
15K
R547
15K
R545
R546 47K
C522 .1
R550 2.2K
R549 47K
C523 5MFD
OUTPUT BIAS, J500, PIN 5
R555 100K
R554 100K
-380, J500, PIN 4
R552 825K
R553 30.1K
R551 47.5K
OUTPUT BIAS, J500, PIN 3
NOTE
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN MICROFARADS
UNLESS OTHERWISE SPECIFIED
EFFECTIVE SERIAL NO 117
SCHEMATIC DIAGRAM
POWER AMPLIFIER
MODEL 323C
HOLT INSTRUMENT LABORATORIES


T100
NOTE
PRIMARY SHOWN ON POWER AMPLIFIER
S601-E
S602-D
S602-C
S603-C
LOW FREQ T102
HIGH FREQ T600
S600-R
S600-P
S600-L
S600-N
S600-M
K600-C
K600-B
K600-A
K600-D
S600-K
S103-B
T601 RATIO
S103 RANGE SELECTOR
1-1000 V
.1-1V
.01-.1V
J104 OUTPUT
J105 1 VOLT 10 AMP
J106 COMMON
LINK
GND J107
+6VDC
S600-S
INTERNAL OSCILLATOR J200-5
K600
6VDC COMMON
DS 105 DANGER LIGHT
S103-A
S600 100 VOLT STEPS
S601 10 VOLT STEPS
S602 1 VOLT STEPS
S603 .1 VOLT STEPS
S604 .01 VOLT STEPS
R646 0-.01 VOLT VERNIER
S600-E,F,G,H,J
S601-D
R618 200
S600-A
S602-B
S601-A
S603-B
S604-A
R662 25 9
R663 100
R646 100
COMMON
AC-DC CONV.
J700-1
C601* 10PF
C622 75PF
J800 PIN5 SERVO CKT
R647 1K
S602-A
S603-A
R661 1.5K
S101-B STAND-BY, OPERATE + INPUT TO POWER AMP.
S103-B
S600-B
S601-B
SIGNAL COMMON
POWER AMPLIFIER INPUT ATTENUATOR
C600* 680PF
C602* 800 PF
C603* 910 PF
C604* 1300 PF
C605* 1600 PF
C606 2400 PF
C607* .0047
C608* .01
S601-C
C609* 2000 PF
C610* 1600 PF
C611* 1300 PF
C612* 800 PF
S600-C
C613* 1600 PF
C614* 1500 PF
C615* 1300 PF
C616* 1200 PF
C617* 910 PF
C618* 500 PF
C619* 27PF
C620* 10PF
C621* 10 PF
S600-D
FREQUENCY COMPENSATION
(WIRING IS FACTORY SELECTED)
NOTE:
* FACTORY SELECTED VALUE, NOMINAL VALUE SHOWN ALL SWITCHES SHOWN CCW OR ZERO DIAL POSITION RELAY SHOWN DE-ENERGIZED.
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN MICROFARADS
UNLESS OTHERWISE SPECIFIED
EFFECTIVE SERIAL NO. 100
SCHEMATIC DIAGRAM
VOLTAGE SWITCHING + ATTENUATOR
MODEL 323C
HOLT INSTRUMENT LABORATORIES
OCONTO, WISCONSIN



NOTE

*FACTORY SELECTED VALUE, OPTIMUM VALUE SHOWN.

ALL CAPACITOR VALUES IN MICROFARADS

ALL RESISTOR VALUES IN OHMS

UNLESS OTHERWISE SPECIFIED.

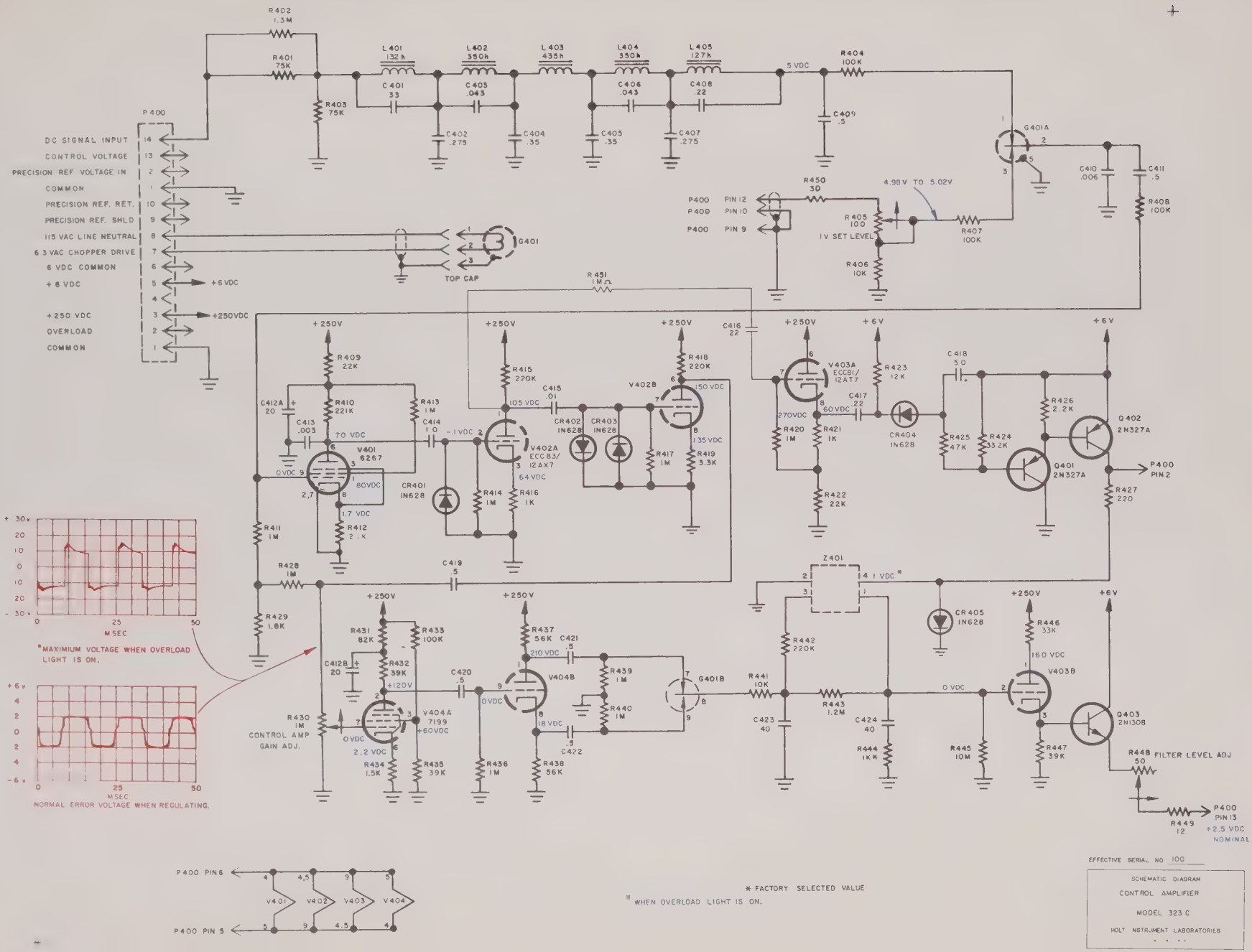
EFFECTIVE SERIAL NO 100

SCHEMATIC DIAGRAM

AC/DC CONVERTER

MODEL 323C

HOLT INSTRUMENT LABORATORIES

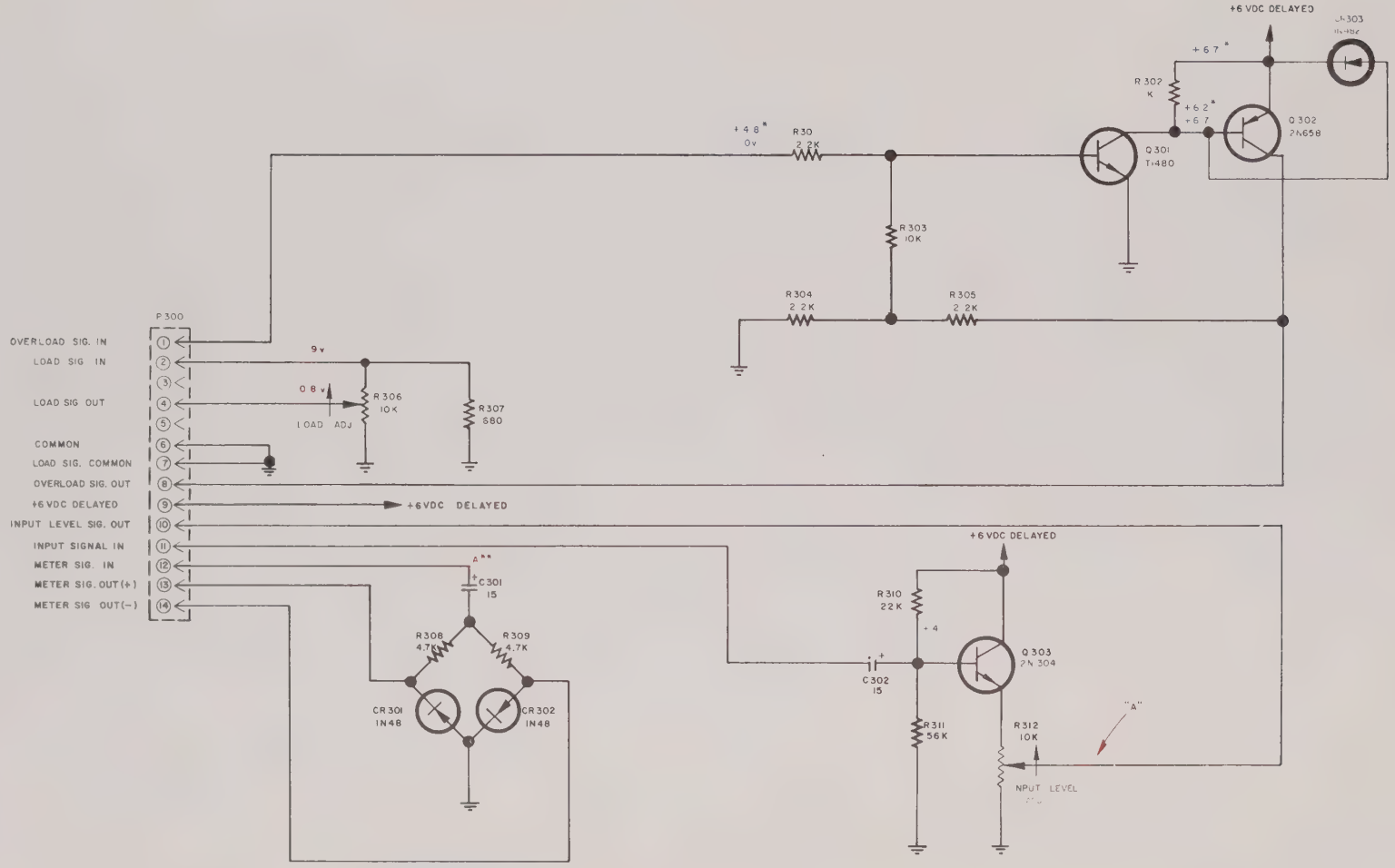


* FACTORY SELECTED VALUE

* WHEN OVERLOAD LIGHT IS ON.

EFFECTIVE SERIAL NO 100

SCHEMATIC DIAGRAM
CONTROL AMPLIFIER
MODEL 323 C
HOLT INSTRUMENT LABORATORIES



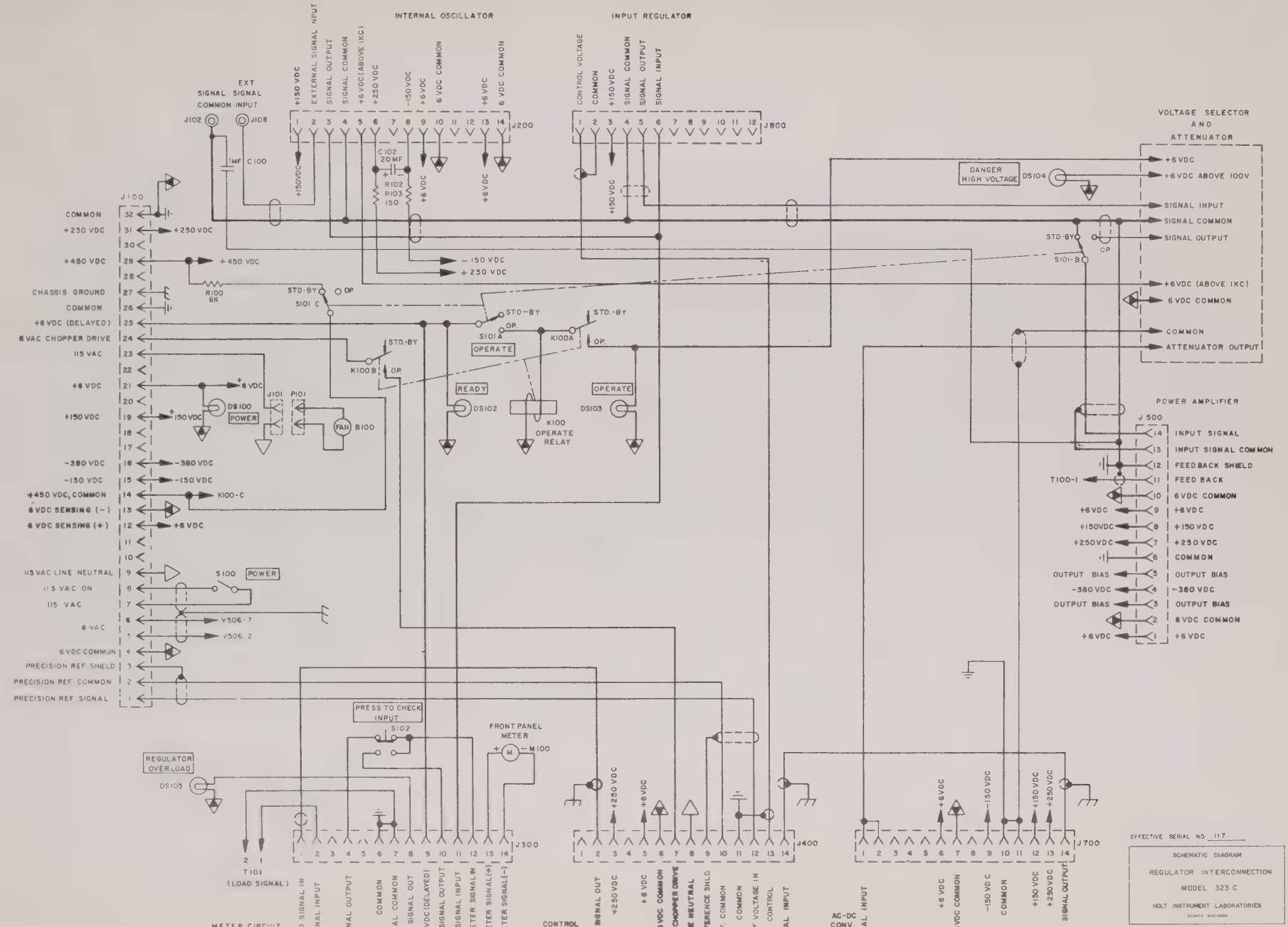
* CONTROL AMPLIFIER SATURATED, OVERLOAD LIGHT ON

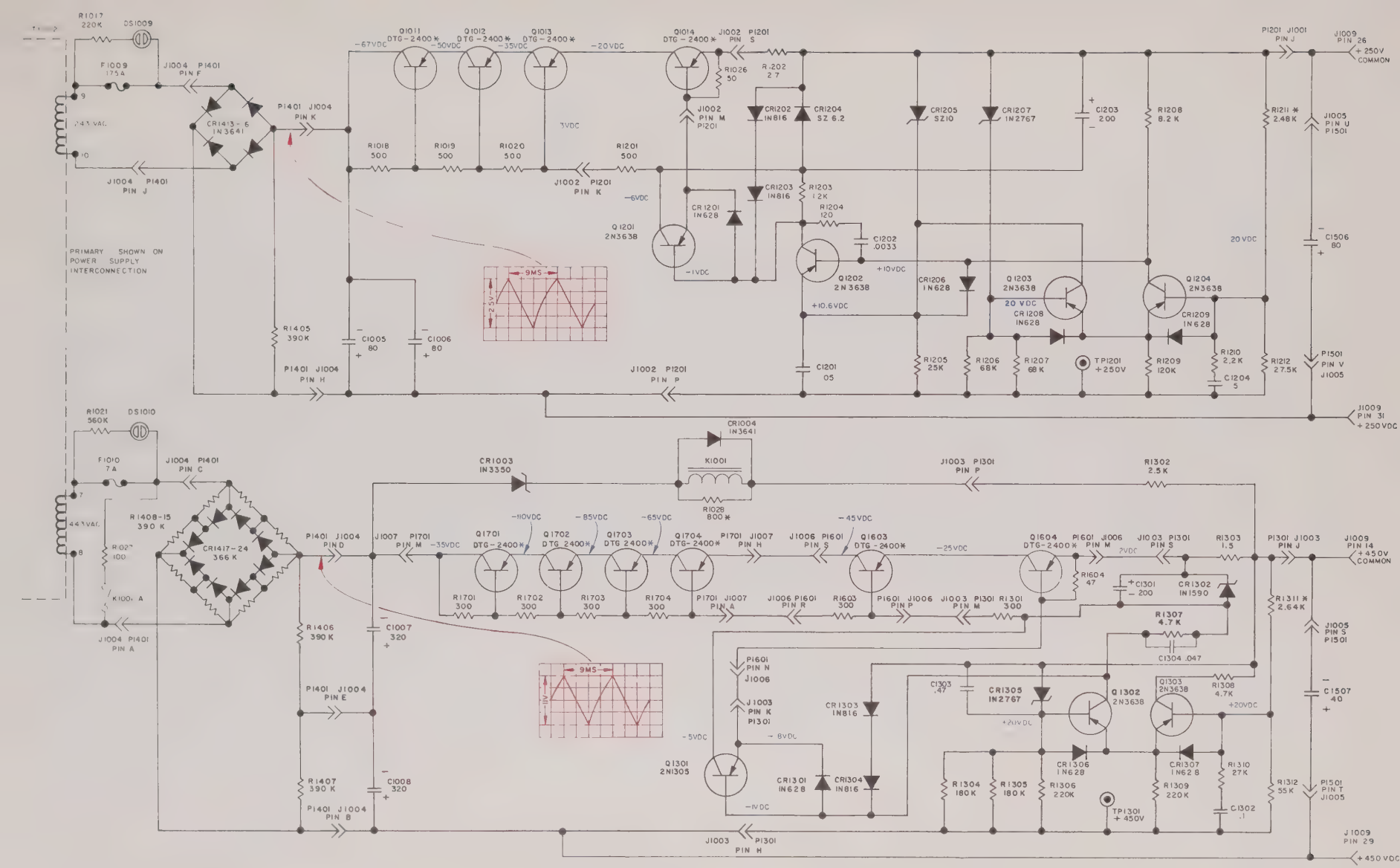
"A". VOLTAGE VARIES WITH "PRESS TO CHECK INPUT" BUTTON
BUTTON NOT PRESSED. 2.1 v
"A" BUTTON PRESSED 1.4 v

NOTE
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN MICOFARADS
UNLESS OTHERWISE SPECIFIED

EFFECTIVE SERIAL NO 100

SCHEMATIC DIAGRAM
METER
MODEL 323C
HOLT INSTRUMENT LABORATORIES


INTERNAL OSCILLATOR
INPUT REGULATOR
EXT SIGNAL COMMON
EXT SIGNAL INPUT
J102
J103
1MF C100
+150 VDC
EXTERNAL SIGNAL INPUT
SIGNAL OUTPUT
SIGNAL COMMON
+6 VDC (ABOVE 1KC)
+250 VDC
-150 VDC
+6 VDC
6 VDC COMMON
+6 VDC
6 VDC COMMON
J200
CONTROL VOLTAGE
COMMON
+150 VDC
SIGNAL COMMON
SIGNAL OUTPUT
SIGNAL INPUT
J800
C102 20MF
R102
R103 150
VOLTAGE SELECTOR AND ATTENUATOR
DANGER HIGH VOLTAGE
DS104
+6 VDC
+6 VDC ABOVE 100V
SIGNAL INPUT
SIGNAL COMMON
SIGNAL OUTPUT
STD-BY
OP
S101-B
+6 VDC (ABOVE 1KC)
6 VDC COMMON
COMMON
ATTENUATOR OUTPUT
J100
COMMON 32
+250 VDC 31
+450 VDC 29
CHASSIS GROUND 27
COMMON 26
+6 VDC (DELAYED) 25
6 VAC CHOPPER DRIVE 24
115 VAC 23
+6 VDC 21
+150 VDC 19
-380 VDC 16
-150 VDC 15
+450 VDC, COMMON 14
6 VDC SENSING (-) 13
6 VDC SENSING (+) 12
115 VAC LINE NEUTRAL 9
115 VAC ON 8
115 VAC 7
6 VAC 6
6 VDC COMMON 4
PRECISION REF SHIELD 3
PRECISION REF COMMON 2
PRECISION REF SIGNAL 1
R100 6K
S101 C
S101 A
S101 B
K100 A
K100 B
K100-C
OPERATE
READY
DS102
DS103
K100 OPERATE RELAY
J101
P101
DS100 POWER
FAN B100
S100 POWER
V506-7
V506-2
POWER AMPLIFIER
J 500
14 INPUT SIGNAL
13 INPUT SIGNAL COMMON
12 FEED BACK SHIELD
T100-1
11 FEED BACK
10 6 VDC COMMON
9 +6 VDC
8 +150 VDC
7 +250 VDC
6 COMMON
5 OUTPUT BIAS
4 -380 VDC
3 OUTPUT BIAS
2 6 VDC COMMON
1 +6 VDC
PRESS TO CHECK INPUT
S102
FRONT PANEL METER
M100
REGULATOR OVERLOAD
DS105
T101 (LOAD SIGNAL)
J300
J400
J700
METER CIRCUIT
OVERLOAD SIGNAL IN
LOAD SIGNAL INPUT
LOAD SIGNAL OUTPUT
COMMON
LOAD SIGNAL COMMON
OVERLOAD SIGNAL OUT
+6 VDC (DELAYED)
INPUT LEVEL SIGNAL OUTPUT
INPUT LEVEL SIGNAL INPUT
METER SIGNAL IN
METER SIGNAL(+)
METER SIGNAL(-)
CONTROL AMP.
OVERLOAD SIGNAL OUT
+250 VDC
+6 VDC
6 VDC COMMON
6 VAC CHOPPER DRIVE
115 VAC LINE NEUTRAL
PRECISION REFERENCE SHLD.
PRECISION REF. COMMON
COMMON
PRECISION REF VOLTAGE IN
CONTROL
DC SIGNAL INPUT
AC-DC CONV.
SIGNAL INPUT
+6 VDC
6 VDC COMMON
-150 VDC
COMMON
+150 VDC
+250 VDC
DC SIGNAL OUTPUT
EFFECTIVE SERIAL NO 117
SCHEMATIC DIAGRAM
REGULATOR INTERCONNECTION
MODEL 323 C
HOLT INSTRUMENT LABORATORIES
DORIS WISCONSIN



NOTE

ALL RESISTOR VALUES IN OHMS

ALL CAPACITOR VALUES IN MICROFARADS

* FACTORY SELECTED VALUE.

EFFECTIVE SERIAL NO 100

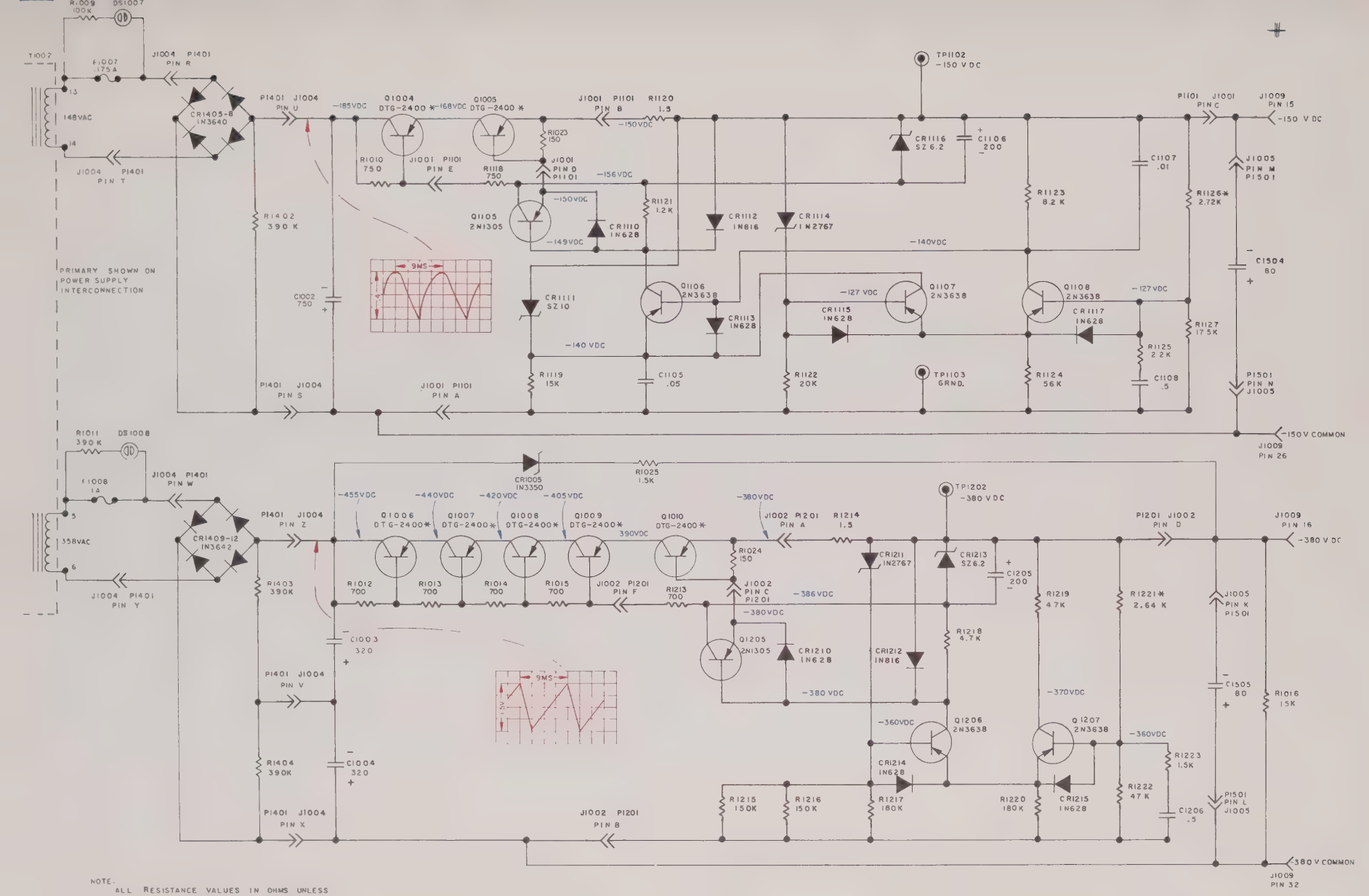
SCHEMATIC DIAGRAM

+250V AND +450V

REGULATORS

MODEL 323 PS/1

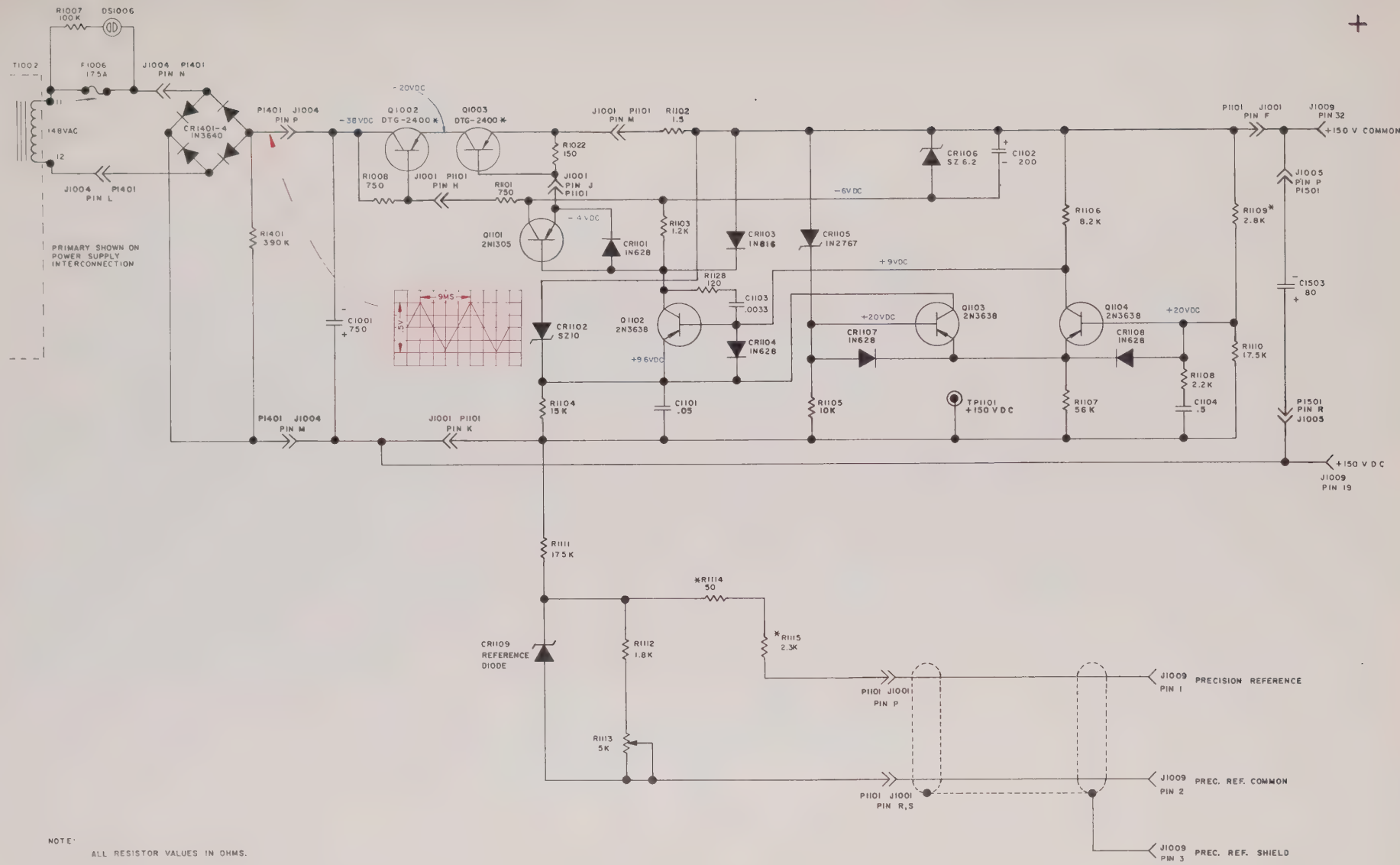
HOLT INSTRUMENT LABORATORIES



NOTE.
ALL RESISTANCE VALUES IN OHMS UNLESS
ALL CAPACITANCE VALUES IN MICROFARADS
* FACTORY SELECTED VALUES

EFFECTIVE SERIAL NO. 100

SCHEMATIC DIAGRAM
-150V AND -380V
REGULATORS
323 PS/I
HOLT INSTRUMENT LABORATORIES



NOTE:

ALL RESISTOR VALUES IN OHMS.

ALL CAPACITOR VALUES IN MICROFARDS

* FACTORY SELECTED VALUE

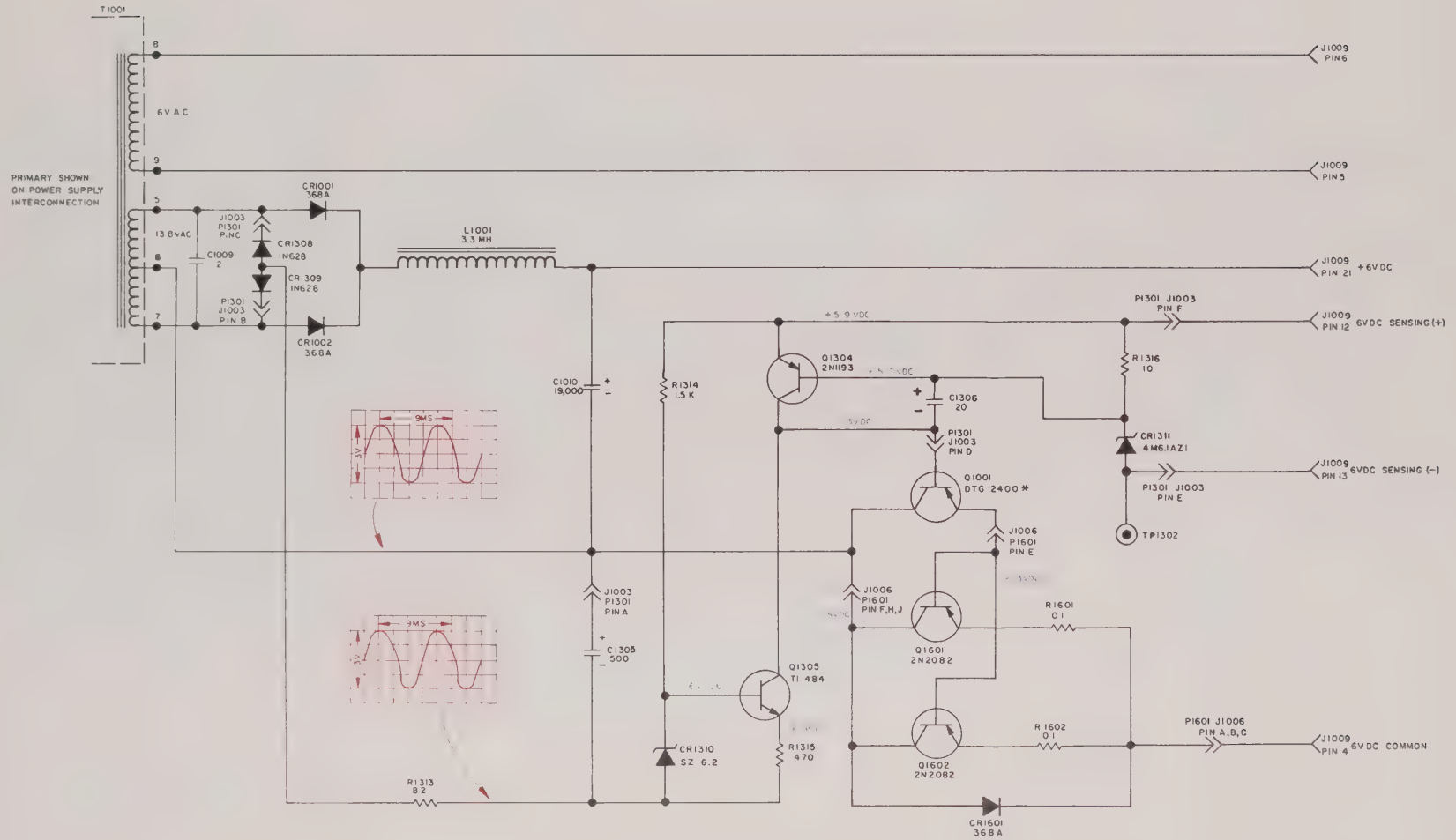
EFFECTIVE SERIAL NO 119

SCHEMATIC DIAGRAM

+150 V REGULATOR AND PRECISION REFERENCE

MODEL 323PS/1

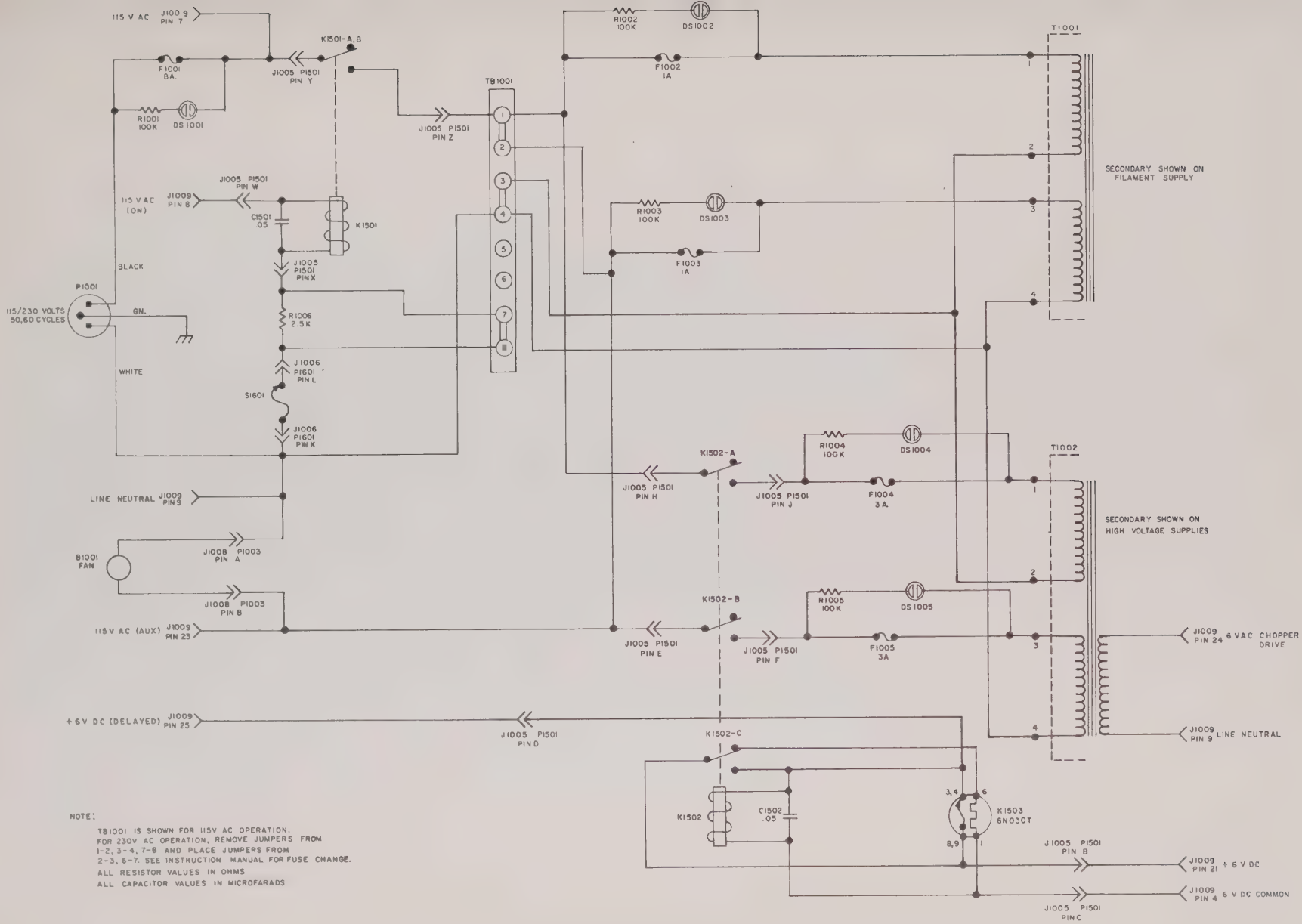
HOLT INSTRUMENT LABORATORIES



NOTE ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN MICROFARADS
* FACTORY SELECTED

EFFECTIVE SERIAL NO 100

SCHEMATIC DIAGRAM
FILAMENT SUPPLY
323 PS/1
HOLT INSTRUMENT LABORATORIES

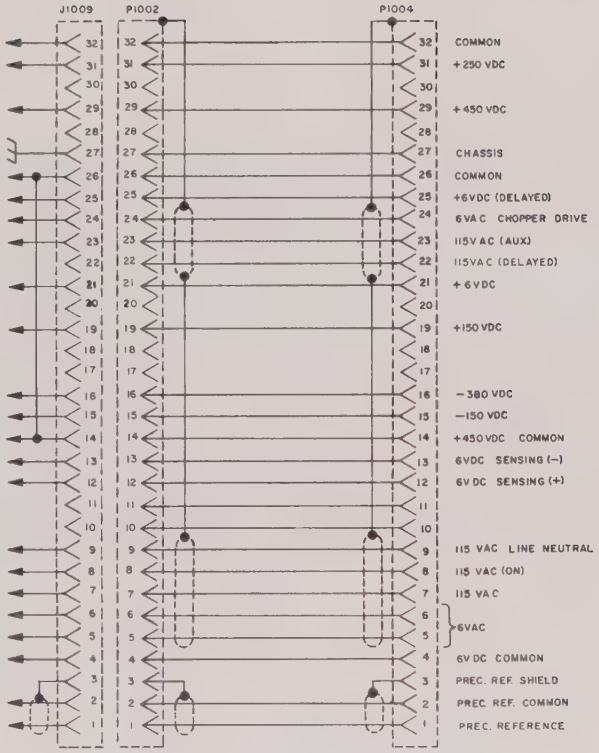


NOTE:

TB1001 IS SHOWN FOR 115V AC OPERATION.
FOR 230V AC OPERATION, REMOVE JUMPERS FROM
1-2, 3-4, 7-8 AND PLACE JUMPERS FROM
2-3, 6-7. SEE INSTRUCTION MANUAL FOR FUSE CHANGE.
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN MICROFARADS

EFFECTIVE SERIAL NO 100

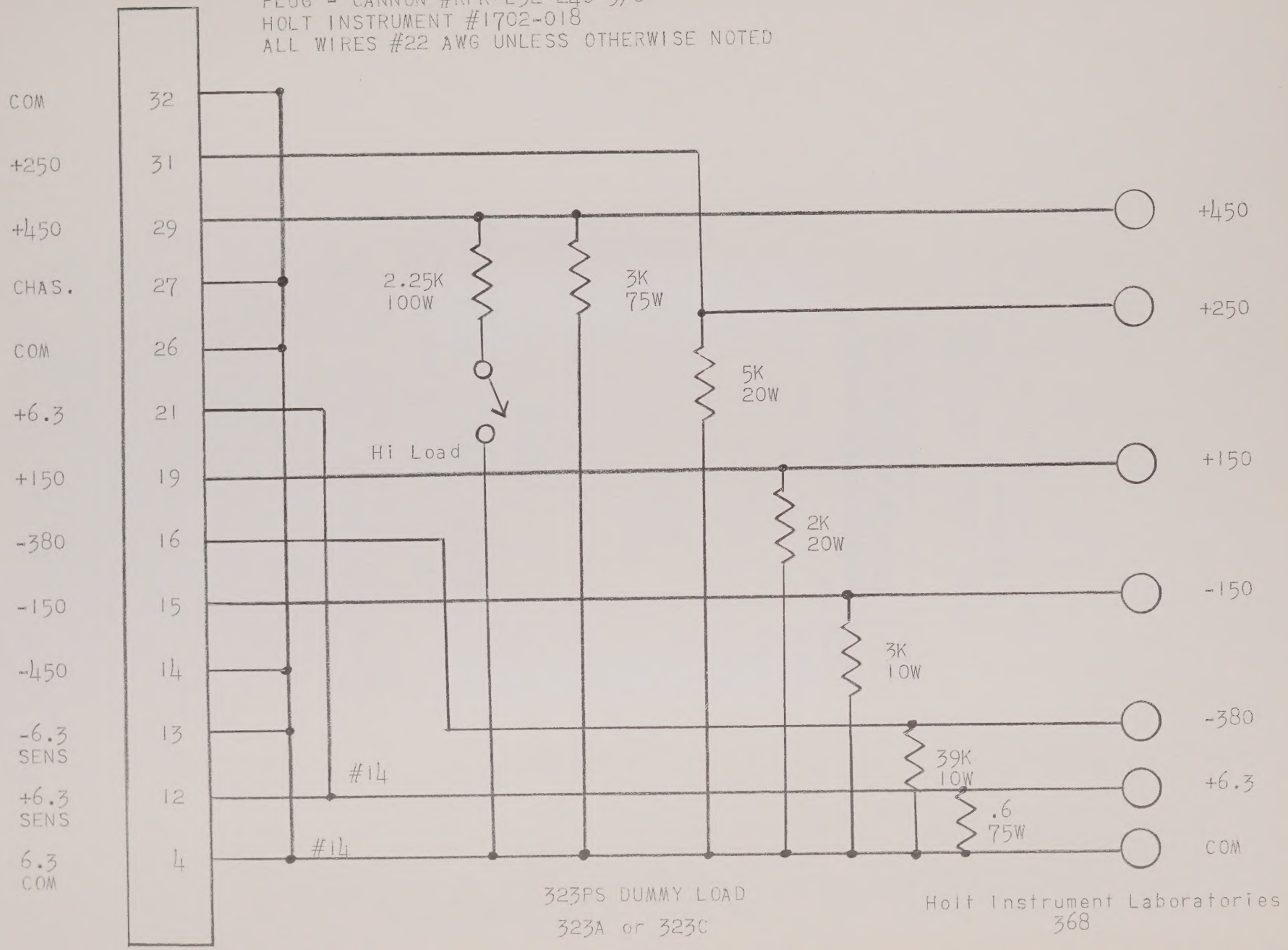
SCHEMATIC DIAGRAM
POWER SUPPLY
INTERCONNECTION
MODEL 323PS/1
HOLT INSTRUMENT LABORATORIES



EFFECTIVE SERIAL NO 100

SCHEMATIC DIAGRAM
INTERCONNECTING
CABLE
323 PS/1
HOLT INSTRUMENT LABORATORIES

PLUG - CANNON #RFK-L32-24C-5/8
HOLT INSTRUMENT #1702-018
ALL WIRES #22 AWG UNLESS OTHERWISE NOTED



323PS DUMMY LOAD
323A or 323C

Holt Instrument Laboratories
368

NO: ME 1765
TITLE: AUDIO VOLTAGE STANDARD
MODEL 323C

c.2

NAME/PHONE/ORGANIZATION | DATE

ME 1765
c.2

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